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EDITOR'S OUTLOOK

IT GIVES a feeling of satisfaction to turn to another of the winners of the Nobel Prize in chemistry. For here are men whose long labors have not gone entirely unrecognized or unrewarded. Richard Zsigmondy received it in 1926 for the year 1925 for "his exposition of the heterogeneous nature of colloid solutions, and for the methods he used in that connection, which have become a determining factor in the modern chemistry of colloids." We read in his autobiography that he was grateful for the money the prize brought him because the ravages of the war had visited upon the University of Göttingen as it had upon all Germany, and he and his colleagues were unable to buy the more expensive of the chemicals that were necessary for carrying on their research. We catch a further glimpse of the far-reaching effects of war—a picture of scientists, citizens of the world and laborers for all humanity, standing with hands tied. We see, too, something of Zsigmondy's determination when he adds that experimentation went forward, nevertheless, with what little equipment they did have.

Richard Zsigmondy, 1865–1929

Zsigmondy was born on April 1, 1865, in the city of Vienna. His was a double heritage—that of brilliant and educated parents and, as a result of their genuine interest in their children's development, that of an excellent training. His father was famous in the field of plastic surgery and did much to develop dentistry in his own country; and his mother, from the little we know of her, was a courageous character, something of a linguist and a lover of poetry, who never put her womanly fears in the way of her children's natural aptitudes. She must have been apprehensive, for instance, when the two older boys took to mountain climbing. They in time became noted for it. She must have been apprehensive, too, when Richard exhibited this same love of danger in the matter of chemical experiments. Once, he tells us, having been forbidden by his father to make hydrogen sulfide from iron sulfide and acid, he decided to try out zinc sulfide. He mixed zinc filings and sulfur in a wide-mouthed flask of his own fashioning, and heated them by means of an alcohol lamp. His patience being tried because nothing happened for a long time, he substituted a blowpipe for the alcohol lamp with the result that the contents and flask exploded, many glass particles lodging in his face.

He received his doctor's degree in 1889 at Munich and for a few years was an assistant in physics to Professor Kundt at Berlin. In 1893 he went to the Technische Hochschule in Graz as a teaching assistant. It was about this time he became interested in the colors of porcelain glazes, and found they were due to finely divided particles of gold which produced different colors with different metallic oxides present in the porcelain. Zsigmondy first spoke about colloidal gold before the German Electrochemical Society in Leipzig in 1898. This classical work marked

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the beginning of his researches on colloids, the field of chemistry in which for years he has been one of the most prominent figures. In 1897 he went to work with Schott and Company in Jena, where he developed the well-known, exceptionally uniform Jena "Milchglas." It has been said that the most tragic aspect of the modern trend of affairs is the desertion of men from the field of pure research to the industrial world because the universities can pay so little and the money is such a temptation (and necessity, we may add). We may rejoice that Zsigmondy saw this danger and escaped. Back he went in 1900 to the post of private teacher, remaining in Jena until 1907 when he was called to the University of Göttingen. Here he rose to Professor and Director of the Institute of Inorganic Chemistry, a position which he held until February, 1929.

He was married in 1903 to the daughter of Wilhelm Müller, professor of pathology at the University of Jena. They had two children, Anne Marie and Käthe, the former of whom married Dr. Erich Hückel of Göttingen with whom Zsigmondy later collaborated.

It was while in Jena that Zsigmondy, aided by the physicist, Siedentopf, constructed the ultramicroscope, by means of which it was possible to observe the hitherto invisible colloidal particles. This instrument was still further refined at Göttingen and has proved invaluable in the investigation of colloidal phenomena. During his first years at Göttingen he directed his attention to the study of gels and gel structure. Since the war ultrafiltration has been the primary interest at Zsigmondy's Institute, and membrane and ultra fine filters have been developed which have been invaluable in determining particle size.

His publications include works on Cassius purple, on the absorption of light by colored glass, on the ultramicroscope (with Siedentopf), and on technical gas analysis (with Jander, 1920) as well as the books, "Zur Erkenntnis der Kolloide" (1905), "Kolloidchemie mit besonderer Berücksichtigung der anorganischen Kolloids" (1907), and "Kolloidchemie" (1912, revised 1927).

The human side of him was not swallowed up in his research. He was a loved and esteemed teacher. When he appeared in the laboratory a group would immediately gather about him and he would take the cigarette—not the proverbial pipe—from his mouth, and talk to them and discuss their problems. He fought sorrowfully against failing health, realizing that it was limiting the scope of his work. He died on September 24, 1929. "Science has suffered a great loss," begins a timely obituary. Science has not suffered. Death comes to us all. Happy those who can so well achieve before it lays its hand upon them.

The JOURNAL OF CHEMICAL EDUCATION *gratefully acknowledges the courtesy of Dr. W. A. Patrick, a former student of Zsigmondy, and now of The Johns Hopkins University, for the accompanying photograph.*

IT HAS been suggested from time to time with more or less seriousness that what our country really needs most is a ten-year vacation for Congress. There are times during every session when the bystander is inclined to agree.

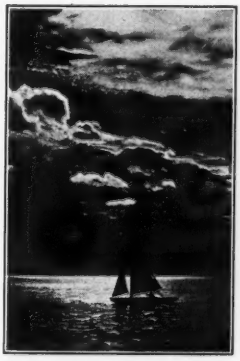
Hoping You Are the Same—

It is probably too much to expect that a month's vacation from editorial comment, criticism, and prophecy will prove as salutary to chemical education as might a ten-year legislative holiday to the country at large. In the first place, editorials with which one doesn't agree can be deposited in the waste basket or buried in the files; legislation usually forces itself upon one's attention via the lower right-hand corner of the tax-bill, if in no other way.

Nevertheless, slight as may be the resultant good to all concerned, we are public spirited enough to make the experiment. If our readers will refrain from reading any profound and scholarly dissertations on chemical education and its problems this month we will refrain from writing any. (Perhaps that *isn't* so much of a change, after all, but let's be liberal.)

Dr. Bancroft's coagulation theory of anesthesia and insanity suggests the possibility that hot-weather ratiocination may not be worth so much after all. We seem to remember that heat is a protein coagulant, and we know that (for us, at least) it is an anesthetic. Dr. Bancroft is welcome to make whatever use he can of this idea, though presenting Dr. Bancroft with an idea is like sending a cargo of coal to the mayor of Newcastle.

Personally we're going where the brook trout flourishes *and bites*, and we're going to try to get there before the black fly begins to emulate him. We hope you can do the same. But if you can't you may derive some cheer from the reflection that when we're back on the job, embalming great thoughts in printer's ink, your vacation will be just beginning.



A Monarch of the Cork Forest

CORK AND ITS USES

GILES B. COOKE, ARMSTRONG CORK COMPANY, LANCASTER, PENNSYLVANIA

Cork is the bark of the cork oak which is found along the shores of the Western Mediterranean. When the tree is twenty years old the cork is stripped from the trunk and at nine-year intervals thereafter.

Cork is composed of tiny air-filled cells held together by a natural resinous binder. Because of this structure cork is light, compressible, resilient, and waterproof. Cork has a low thermal conductivity and a high coefficient of friction.

Cork has been shown to contain tannins, phlobaphenes, lignin, and cerin. Glycerin and several acids have been obtained by saponification.

Natural cork is used to manufacture stoppers, life preservers, and many other articles. Scraps of cork are ground and used in the manufacture of cork composition from which gaskets, polishing wheels, crown seals, and numerous other articles are made.

Corkboard for insulation and cork tile, cork carpet, and linoleum for floors, are manufactured from cork.

. . . . . .

History

The beginning of the cork industry can be traced back to more than two thousand years ago. The cork oak and its products were well known to the ancient Greeks and Romans. Theophrastus describes cork in his famous work on botany, "*Historia Plantarum.*" Pliny tells of its use for stoppers, floats, and shoes in his "*Naturalis Historia.*" Horace refers to cork as a closure for wine vases, and according to Virgil cork slabs were used for roofs of houses. Plutarch gives the following account of its use by a messenger sent to Rome at that time besieged by the Gauls:

> Pontius Comminius, having dressed himself in mean attire, under which he concealed some pieces of cork could not pass the river by the bridge, therefore he took off his clothes which he fastened upon his head, and having laid himself upon the pieces of cork swam over and reached the city.

In later days cork was used to make barricades on English naval vessels. From Samuel Pepys' diary, we read:

> 14 July, 1666—After having written to the Duke of York for money for the fleet, I went down to Thames Street and there agreed for from four to five tons of cork to be sent to the fleet, being a new device to make barricades with instead of junts (old cables).

Notwithstanding these applications of cork its general use was limited and remained so until the middle of the eighteenth century. The first traces of special culture of the cork oak began in Spain in 1760. A resident German leased several cork forests, put them under regular cultivation, and exported the cork to Germany. This example was soon followed by

THE DISTRIBUTION OF THE CORK OAK IN WESTERN EUROPE AND NORTHERN AFRICA

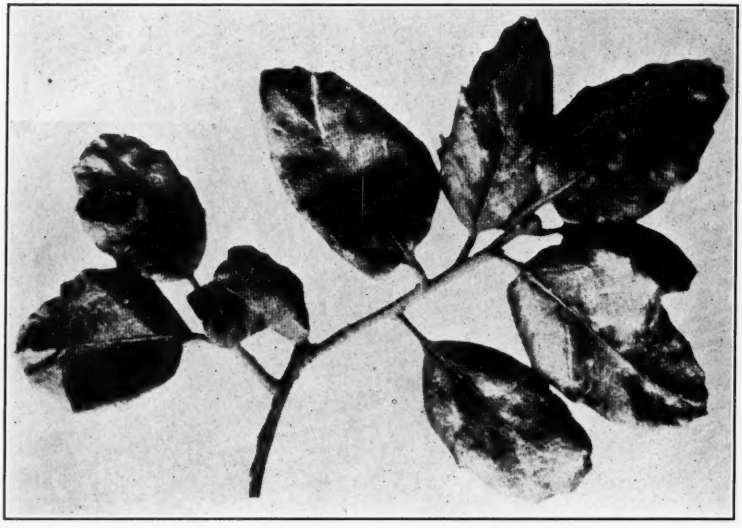
others and the cultivation of cork by 1830 had spread into France, Portugal, Italy, and northern Africa.

Growth and Cultivation

The widespread use of cork stoppers today has made almost every one acquainted with cork. Yet there is no natural product so universally used about which so little is known. This interesting material has many applications in its natural condition, and it is compounded with other materials to make many valuable products.

Cork comes from the cork oak, being a thick protective bark for this species of the oak tree. This oak grows only in certain regions and is found chiefly around the Mediterranean Sea. Portugal is the largest producer of cork and Spain ranks second. Large quantities of cork are also produced in northern Africa, in Algeria, Tunisia, and Morocco. Some cork is also produced in southern France, Italy, and the island of Corsica.

Gnarled Trunk of an Enormous Old Cork Oak



LEAVES OF THE CORK OAK

Similar in shape to the holly leaf, but soft as velvet to the touch.

There are two species of cork oaks—the *Quercus Suber* and the *Quercus Occidentalis*—the chief difference being in the duration of their foliage and the structure and ripening season of their fruits. Although both species belong to the evergreen oaks and have perennial foliage, the *Quercus Occidentalis* loses its leaves in the early spring of the second year while those of the *Quercus Suber* remain on the tree for two or three seasons. The cork oaks grow to a height of thirty-five to forty-five feet, and measure from nine to fifteen feet around the trunk. They live for about one hundred years and produce eight or nine crops of cork.

The cork acorns ripen in the fall and are usually fed to swine. The piquant flavor of Spanish hams is said to be due to these acorns. Hogs range through the cork forests rooting out underbrush, thus reducing fire hazard. The hog grower pays for this privilege. The hogs are weighed before and after the season, and the owner of the cork forest is paid according to the gain in weight.

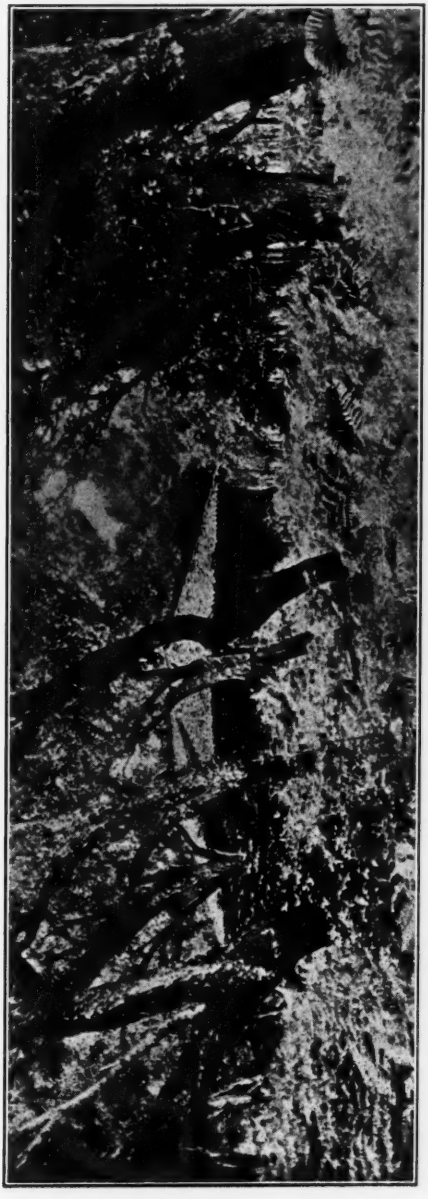
Cork requires from eight to ten years for growth. If a large cork stopper be carefully examined, the annual rings showing the yearly growth can be seen distinctly. Seasonal differences affect the growth of cork and these variations can be seen in the varying widths of the annual rings.

Cork is the outer bark and is only a protective coating for the oak tree. When about twenty years old the cork oak is ready for its first stripping.

The cork removed at this time is called virgin cork. It is of an inferior quality and the second stripping furnishes a much better grade. However, it is not until the third stripping that a really fine quality of cork is obtained.

Stripping is carried out during the summer months. The cork must be very carefully removed, for if the inner bark is damaged no more cork will grow. Cuts are made around the tree, at the ground and at the top of the trunk. Then the bark is split vertically in two places—making use of the natural crevices—and the cork is forced off the tree. In some places cork is also removed from the larger limbs, but in North Africa the French government prohibits the stripping of the branches.

When the cork is removed from the trees it is stacked in piles and dried in the air for several days. The cork is then weighed on the type of scale—the Romano—which was introduced by the Romans almost two thousand years ago.

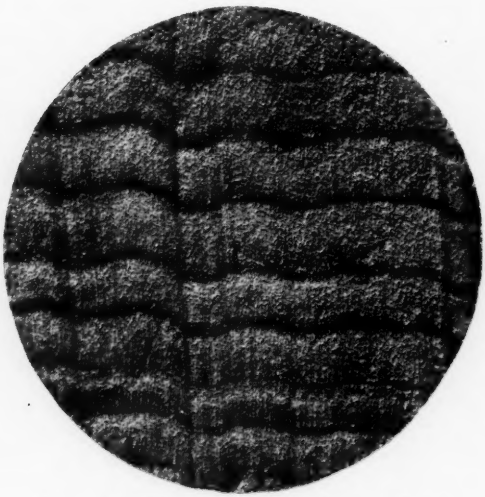


A CORK OAK FOREST IN LANDES, FRANCE
France, with Corsica, ranks third in cork production among the countries of Western Europe.

Preliminary Treatment

The cork is then ready for boiling and is conveyed to the boiling station. Boiling is carried out in large tanks over open fires. Large bundles of cork are lowered into the tanks by means of a block and tackle. The tanks are about nine feet in length and depth and about six feet wide. They are half-filled with water, which is kept boiling and the cork is kept submerged by weights for half an hour. This boiling process removes tannins and sap and softens the cork. Also the hard coating on the outer surface of the cork, "hardback," is loosened by the hot water and this is later scraped off. By this treatment the cork bark loses about fifteen per cent of its original weight.

After the cork slabs have been boiled and scraped they are trimmed, graded, and baled. Each bale weighs about one hundred fifty pounds.



SECTION OF CORK SHOWING THE ANNUAL RINGS

There are many grades of cork and so slight is the difference between some of the grades that only an expert can notice it. Before shipment to the United States cork is sorted into a dozen or more grades of different qualities and thicknesses by expert sorters. Again in this country the cork is graded by skilled sorters into approximately a hundred classes.

The importance of this classification cannot be over-emphasized as the economical manufacture of all cork products depends upon utilizing the proper quality of cork for each process. The very finest quality of cork is needed for high-grade stoppers, while stoppers for certain uses can be cut from less perfect cork. Bark that is very porous, or very thin, is ground and used in composition products.

Microscopic Structure

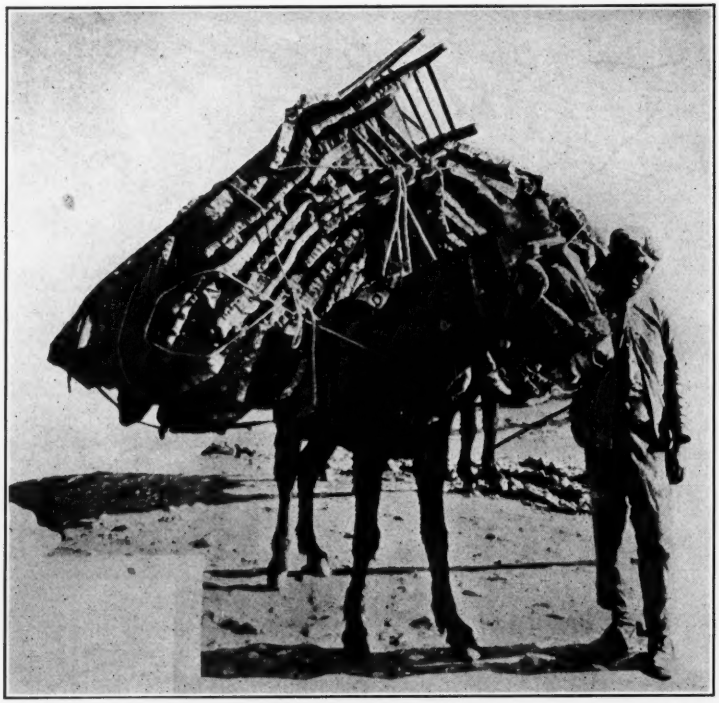
When a microscopic study of the structure of cork is made, the reasons for its characteristic properties can be more clearly seen. Under the micro-

STRIPPING CORK FROM A TREE IN SOUTHERN FRANCE
Care must be taken not to injure the inner bark.

scope cork is shown to be composed of very small cells, having many sides. It has been shown that fourteen cork cells touch each individual cell (*1*). The cells are closely packed, and when individual cells are isolated they rearrange to six-sided figures.

The exact size of cork cells depends on the time and the conditions of growth. They average about two-ten-thousandths of an inch in diameter. The cell walls are very thin and their volume forms but a small fraction of the total volume of the cells.

Between the walls of the cells can be seen a thread-like layer of darker material. This substance has resin-like properties and binds the cork cells together. The cells are apparently filled with air. (See page 1475 for a photomicrograph showing this characteristic cellular structure.)



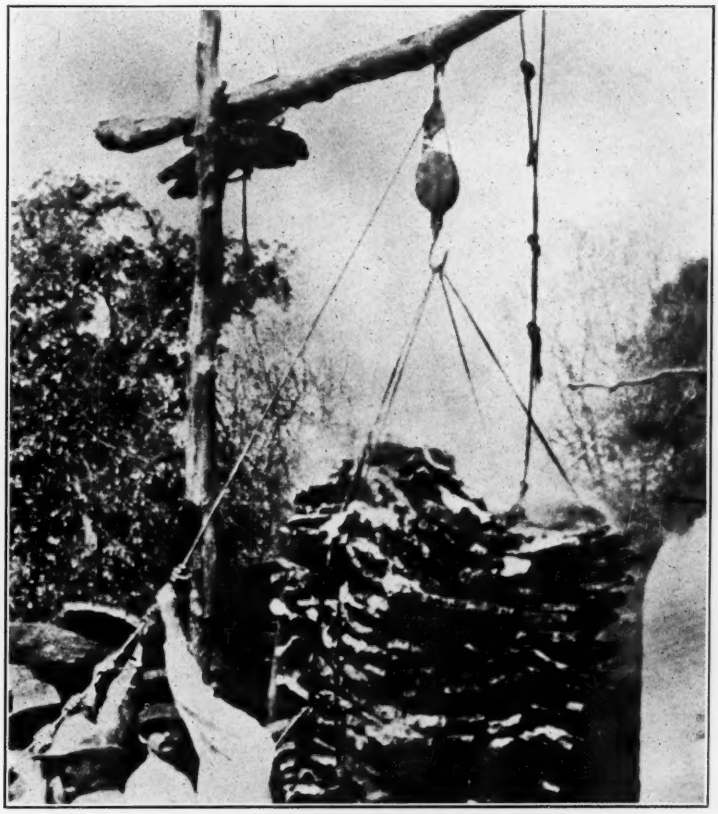
BURRO LADEN WITH CORK

This little animal is not overloaded, for cork is very light.

Physical Properties

The conditions under which cork is formed in nature are responsible for its unique and valuable physical properties. Through a ten-year period of very slow growth, and in an arid, windy climate, exposed to abundance of sunlight, cork develops as a protective coating for the oak tree. It is natural then to expect cork to have at least some of the properties of wood, and other properties which have resulted from changes due to sunlight and heat in a dry atmosphere over a long period of time.

Cork is light, compressible, resilient, waterproof, and a non-conductor of heat. It possesses a high coefficient of friction, and has a relatively high tensile strength. These properties are responsible for the varied and indispensable applications of cork. By referring to the photomicrograph (page 1475) of cork, the reasons for these characteristic properties can be more clearly seen.



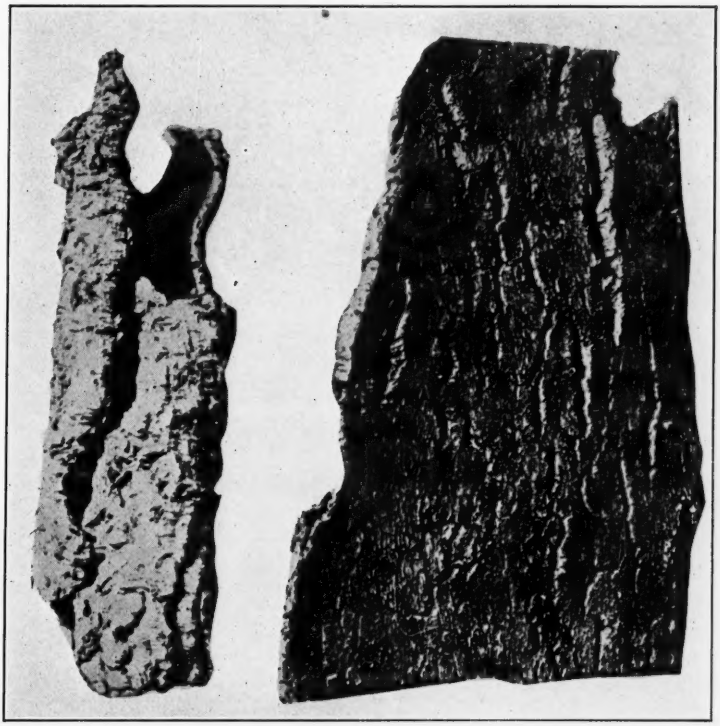
Boiling Cork Bark Preparatory to Scraping and Baling
A batch is being lifted from the vat of hot water.

Air-filled cells with very thin walls make up the greater part of the volume of a piece of cork. This explains why cork is light and buoyant, and makes possible its use in life preservers, in floats for gasoline gages, and in many other places where a material of low density is needed.

Cork is compressible and resilient, and tests made on one-inch cubes of cork have shown that 14,000 pounds of pressure per square inch could be applied to cork without breaking the cells or permanently affecting the strength of the cork cubes. After this enormous pressure had been removed the cork returned to ninety per cent of its original height, while the sides of the cube still measured one inch.

The cork cells and the natural resinous binder which holds them together

WORKERS AT THE ENTRANCE OF THE BALING STATION, ALDEA GALLEGA, PORTUGAL
Note the huge pile of cork inside the yard.

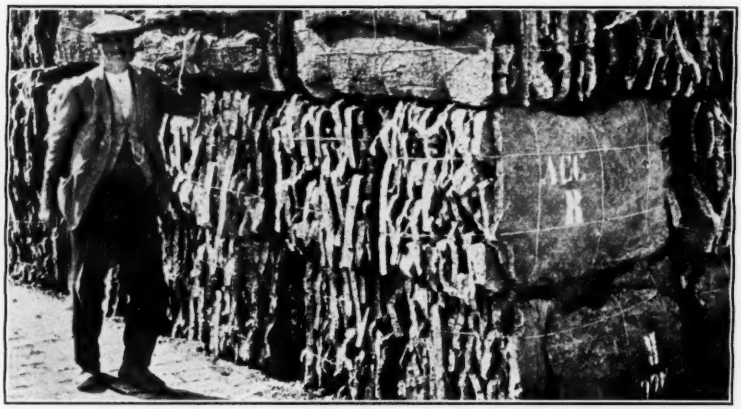


CORK AS IT COMES FROM THE TREE
The piece on the left is virgin cork and is used for grinding only.

are impervious to water, giving cork an extensive use where a moisture-resistant material is needed. In a large cork stopper tiny pinholes can be seen and it is only through these openings that water can enter a piece of cork. The moisture-proof properties of cork protect the cork oak from the parching winds of southern Spain by preventing evaporation of the moisture in the tree.

The low thermal conductivity of cork is due to the air-filled cells which number about one hundred million to the cubic inch. Heat conduction through a piece of cork must take place along the cell walls and therefore along a very curved path. And because the cell wall is but a very small fraction of the total volume of a cell, the number of such curved paths for heat transfer is relatively small.

When one cuts through a piece of cork a great number of the hollow, air-filled cells are cut. These cut cells furnish innumerable cups which



BALES OF CORK STACKED FOR SHIPMENT TO THE UNITED STATES

give to cork the high coefficient of friction which it possesses. When a piece of cork is drawn over a smooth surface partial vacuums are formed in these cell cups, suction is created, and the two surfaces grip each other. Dust from raw cork is an efficient material for removing dirt from the hands because of this high coefficient of friction.

Thus we see that the physical properties of cork are due in no small degree to its air-filled cellular structure. And it is the possession of all these properties by a single substance that has given cork its indispensable place in industry.

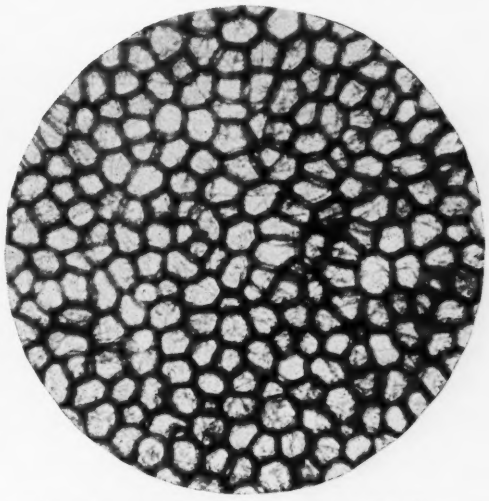
Chemical Properties

Very little is known concerning the chemical composition of cork. For over a hundred years chemists have been endeavoring to determine the nature of its constituents, but the literature is full of contradictions and the amount of definite information available is very limited.

Tannins, phenols, and hydroxybenzoic acids are very generally present in plant tissues. Among the more commonly occurring phenols are phloroglucinol, resorcinol, and hydroquinone; of the hydroxybenzoic acids, gallic, salicylic, and protocatechuic are most frequently found. Some of these substances are widely distributed, especially tannins and phloroglucinol. It has been suggested that tannins may serve as a reserve food supply, but this has not yet been proved. It is generally believed that tannins and other aromatic compounds play an important part in the lignification of wood constituents. Very little is definitely known, however, as to the function of these bodies in plants.

Cork contains tannins and a considerable portion of these are removed in the boiling of cork. But even the finest grade of bleached stopper has some

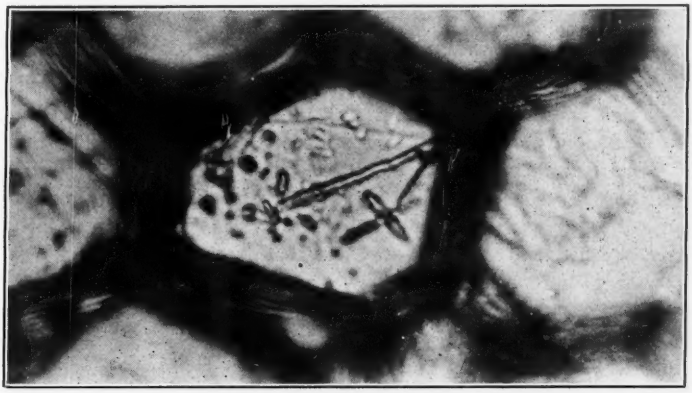
residual tannin and its presence can be shown by extracting a cork stopper with water, or alcohol, and precipitating blue ferric tannate by the addition of a few drops of ferric chloride solution. The darkening of cork stoppers in bottles containing iron salts is due to the reaction between tannins and iron.



A PHOTOMICROGRAPH OF CORK SHOWING ITS CHARACTERISTIC AIR-FILLED CELLULAR STRUCTURE
Magnification 160×.

Chevreul (*2*) in 1807 reported that he had found gallic acid in cork. Drabble (*3*) in 1906, almost one hundred years later, extracted cork with water and obtained gallic acid. No figures concerning the amount of gallic acid in cork are available, but the percentage is no doubt low.

In connection with the presence of tannins and gallic acid in cork it is interesting to note that Fisher (*4*) has shown that the tannin molecule on hydrolysis yields ten molecules of gallic acid and one molecule of glucose.



INDIVIDUAL CORK CELL
Magnification 1500×

Other acids have been obtained from cork but in just what form they are present is not definitely known. In 1877 Hohnel (*5*) discovered the existence of acid compounds in cork. He showed that cork can be saponified by the action of strong alkalies. Kugler (*6*) confirmed the observations of Hohnel and succeeded in isolating an acid melting at 96 degrees. This compound corresponded to the empirical formula $C_{22}H_{43}O_3$ and Kugler called it phellonic acid. He showed that it acts like a monobasic acid.

Gilson (*7*), in 1890, found by extracting cork with alcoholic potassium hydroxide not only phellonic acid but also two other acids. One of these was a semi-fluid substance having the formula $C_{17}H_{30}O_3$ which he called suberinic acid, and to the other, of the formula $C_{11}H_{21}O_4$, which melted at 121 degrees he gave the name phloionic acid. Although some structural formulas for these acids have been suggested, their exact structures are as yet unproved. Glycerin has been identified in the residues of cork extracts. Possibly the acids are present as glycerol esters, but these have not been obtained by exhaustive extraction of cork with fat solvents.

Even in the finest quality of cork, spots of a reddish brown, powdery substance can be seen; this substance is composed of phlobaphenes. They occur in nature along with tannins and can also be prepared by treating tannins with a dehydrating agent, such as sulfuric acid. Therefore, phlobaphenes are considered as anhydrides of tannins. They are insoluble in water, but dissolve in alcohol and alkaline solutions. Practically nothing is known concerning the chemistry of the phlobaphenes.

Cork also contains lignin and a substance which, although it is evidently not cellulose, is cellulose-like in some characteristics. The cork cell wall is made up of this last substance which is very resistant to chemical action. Cork cells may be boiled for an hour in fifty per cent potassium hydroxide, or in fifteen per cent hydrochloric acid, without any detectable change. Only strong oxidizing agents such as chlorine, nitrogen dioxide, or hydrogen peroxide attack the cork cell wall readily.

Cerin, so called because it was first thought to be a wax, is also found in cork. This is an extremely unreactive substance and very little is known about it. Cerin was first extracted from cork almost a hundred years ago and since then chemists have endeavored to learn its structure but so far no one has succeeded. In fact, there have been no less than a half a dozen empirical formulas proposed, which indicates that cerin is either difficult to purify, or difficult to analyze, or both. That given by Siewart (*8*), $C_{17}H_{28}O$, is probably the correct formula. Cerin is white, forms long needle-like crystals, and melts at about 247 degrees forming a resinous substance. It is soluble in the common organic solvents. Kugler states that cork contains as high as 2.9 per cent of cerin.

There are numerous contradictions in the literature in regard to the quantitative composition of cork. Age, growing conditions, quality of the

cork, and the amount of adsorbed moisture affect the results of quantitative work and no doubt account for some of the differences. G. Zemplin (*9*) gives the following analysis of cork:

Moisture	6.21
Ash	4.12
Alcohol extract	10.50
Alcoholic KOH extract	32.50
Water extract of residue	14.00
Sulfuric acid (1.5%) extract	1.50
Lignocellulose	24.50
Residue resembling cellulose	4.17

The extractions were carried out in the order listed.

Cork is very stable chemically as shown by its use as a bottle closure for thousands of chemicals and solutions, and this fact may be due to long exposure, eight to ten years, in an abundance of sunlight, and in an arid, windy region. Under these conditions polymerizations, dehydrations, oxidations, and condensations have no doubt occurred until the greater part of cork is extremely resistant to reactions of this type. However, there are certain reagents which have decided action on cork. Strong alkalies break down the cork structure, because the binding material between the cells is saponified and removed. Such action does not apparently affect the cell walls. The binding material is evidently a mixture of fatty acids, or their esters, together with lignin.

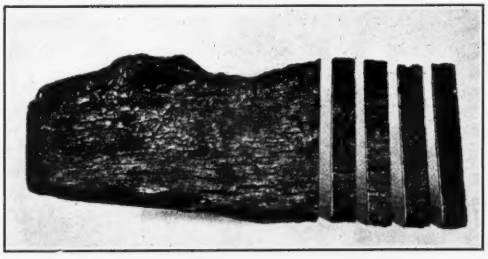
It is well known that lignin readily forms halogen compounds and when cork is exposed to chlorine we get a reaction between the cork lignin and chlorine. If the concentration of chlorine is sufficient the lignin chloride can be removed by subsequent boiling, and the cork particles are reduced to cells. If the chlorine treatment is allowed to act too long, oxidation takes place and the cell walls are attacked.

A large number of chemically pure organic solvents are kept in bottles stoppered with corks, the ends of which are covered with tin foil. These solvents do not destroy the properties of cork, but extract only small amounts of the cork constituents, such as tannins. The corks are coated to preserve the purity of the solvents.

Cork Stoppers

One of the oldest and most widely known uses of cork is the manufacture of stoppers. The varied physical properties of cork make it an ideal material for bottle closures. When a cork stopper is pushed into the neck of a bottle, the cork is compressed, and because cork is resilient it exerts a force against the neck of the bottle, making a tight closure. The high coefficient of friction of cork prevents stoppers from becoming loose and slipping out.

It is difficult to estimate the number of cork stoppers manufactured



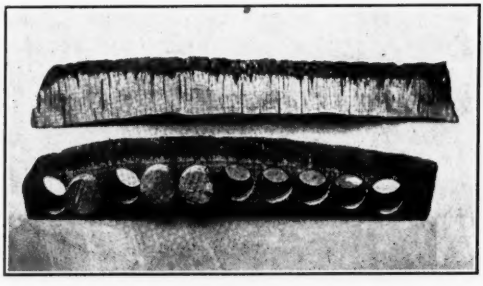
STRIPS OF CORK CUT FROM A SLAB

annually. A conservative figure would be around 10,000,000,000. Corks of all sizes are manufactured, from the smallest medicine stoppers to the largest bungs for kegs. The very finest of all are used for champagne bottles and the inferior grades serve as closures for bottles containing solids.

After the slabs of cork have been carefully graded they are given a steam bath. Exhaust steam is used for this purpose and the pieces of cork are fed into the steam oven at such a rate as to allow from twenty to thirty minutes for steaming. This treatment softens the cork and makes it more pliable and easily cut. As the slabs are taken from the steam oven they are cut into strips, the width of the strips being determined by the size of the stoppers to be punched. The strips are passed before rotating tubular punches which cut out cylindrical pieces with straight sides. The strips are punched perpendicular to the annual rings. Therefore the diameter of a cork stopper is usually no larger than the thickness of cork bark. A limited quantity of large, thin stoppers are made by cutting the cork parallel to the annual rings. Also, laminated cork stoppers are manufactured for certain uses where very large corks are needed.

There is a limited demand for straight-sided corks so most of them are tapered. The corks are fed onto an inclined conveyor which carries them against a revolving cylindrical knife. The conveyor also causes the corks to revolve and they emerge from this operation in the tapered form.

The corks are then bleached and sterilized. This process is carried out in large tubs, the light corks being forced under the water by large revolving paddles. After washing the corks are dried. From the driers the corks pass into baskets and they are carefully graded by trained operators. Finally, the corks are bagged and are then ready for shipment.



NOTE THE DIRECTION IN WHICH THE CORK STOPPERS ARE PUNCHED

MISCELLANEOUS ARTICLES OF NATURAL CORK AND CORK COMPOSITION

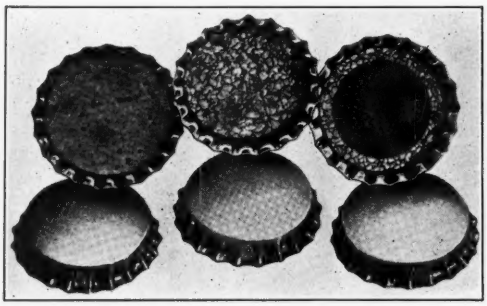
Cork balls, used commonly for baseball centers and surf balls
Composition cork rings for laboratory use
Various types of cork floats for fishermen's nets and seines
Shoe polish swabs with wood-topped cork
Decoy fashioned from natural cork
Novelty pipe, with clay bowl covered with cork composition
Cork insoles, fabric covered
Foundation layer of cork beneath the outside wrapping on golf club handles
Assortment of shell corks, jar corks, and mustard corks
Cork rolls on various types of machinery to feed and draw cloth, paper, etc.
Cork penholder tip
Cork ribbon from which discs for tube and bottle caps are punched
Composition and natural cork bobbers
Natural cork floats used by plasterers

Life Preservers

Another very interesting and indispensable use of natural cork is in the manufacture of life preservers. There are two types, those which are strapped about the body and the circular or "doughnut" type which are known as ring buoys.

In the manufacture of ring buoys dry pieces of cork are trimmed to fit into a ring-shaped mold. A binding material is spread between the pieces of cork and wooden pegs are used to hold them together. The top is placed on the mold, compressing the cork as it is forced down, and made fast with clamps. The mold is then transferred to an oven. This treatment causes the cork to expand and fill in the open spaces between the large pieces, and the binder sets. Afterward, the mold is cooled and the cork ring is removed. Specially cut canvas is sewed around the buoy and rope is attached. Ring buoys must comply with government specifications as to size, weight, and other details.

Life preservers must also meet government regulations. The canvas covers are made first and cork is placed in the pockets and sewed in. The cork must be dry and of good quality. Inferior grades of cork are too heavy, or they may be very porous and too light. The cork may be of one piece, or of several pieces skewered together, and is carefully trimmed and shaped to fit the canvas pockets.



CORK AND CORK COMPOSITION LINERS IN CROWN SEALS

Other Applications of Natural Cork

There are many uses of natural cork which are more or less familiar to every one. Cork is used in the production of sporting goods. Baseballs of the finest grade have cork centers. Fishing rod handles and bobbers for fishing lines are made of cork. Hunters use duck decoys of cork and beach sandals are made with soles of natural cork. Whistles contain small cork balls.

Highly carbonated beverages are sealed with a metal cap, lined with natural cork. Cork liners are used in the caps of containers of many toilet articles. For certain uses corks have a wood top upon which a trade-mark may be embossed. Cork rings reinforce wooden spigots in kegs.

Fishermen employ cork floats for their seines and nets and large mooring buoys are made of cork. Cork floats are used for gasoline gages. Han-

MISCELLANEOUS ARTICLES OF NATURAL CORK AND CORK COMPOSITION

Assortment of natural cork handles
Ring buoy of cork covered with heavy canvas
Natural cork block, used to build up soles of shoes for lame people
Mooring buoys of laminated natural cork
Sheet cork from which many articles of various shapes are cut
Cork table mats
Cork paper shaved from blocks of natural cork and used principally on tips of cigarettes
Heel pads and half insoles from cork composition
Life preserver made of natural cork blocks

dles of tools and penholder tips are made of natural cork. Cork is cut into sheets as thin as tissue paper and is used in the manufacture of cork-tip cigarettes. Insoles for shoes are made of cork and cork is used to build up shoes for the lame.

While there are many other applications of natural cork, these are some of the most important and will serve to show the extensive use of this interesting natural product.

Cork Composition

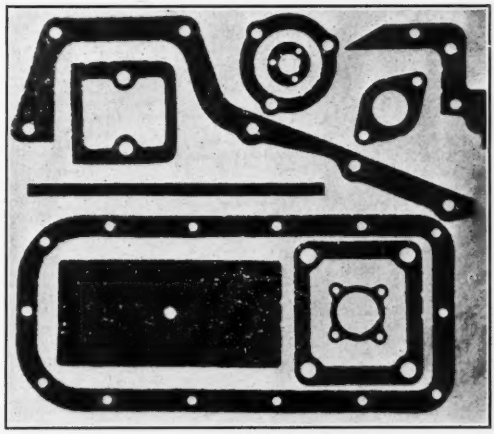
In the manufacture of cork stoppers a large quantity of the cork, about fifty per cent, goes into scrap. This scrap cork is of high quality and is clean and free from hard particles. To waste this scrap would make the price of cork stoppers very high. But the cork industry has found a most important use of this natural cork scrap—the manufacture of cork composition.

SECTION OF CORK COMPOSITION

The scrap formed in punching and beveling cork stoppers is ground to different degrees of fineness and dried. The dry cork granules are mixed with an adhesive material which binds the particles together in somewhat the same manner as the tiny cork cells are held together by the natural cork resin. The cork is placed in large mixers and the proper quantity of binding material is added. Mixing is accomplished by means of revolving paddles which cause every particle of cork to become coated with a very thin film of the adhesive material. The mixture is then transferred to molds where it is compressed to about one-sixth of its original volume. The molds are placed in ovens which are kept at a temperature that does not bake the cork, but causes the binding material to set, thus holding the cork particles together in a single mass. This heating requires from six to ten hours, depending upon the size of the cork particles, the nature of the binding material, and the particular proportions used. After baking, the molds are allowed to cool and the mats are removed. The mats are then cut by sharp revolving circular knives into sheets. The sheets vary in thickness depend-

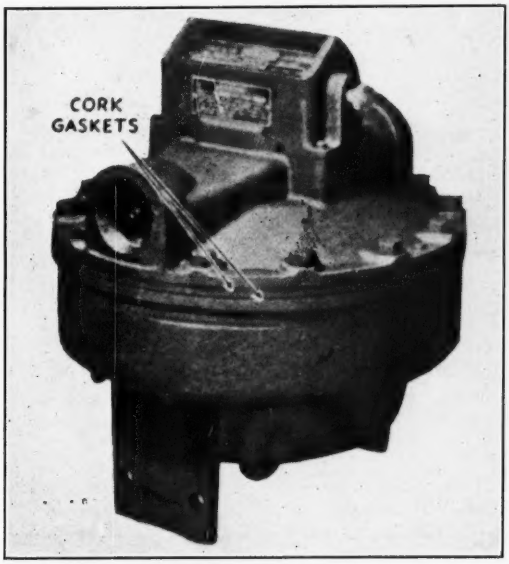
ing upon the particular purpose for which they will be used. From these sheets a large number of important cork articles are made.

There are different kinds of cork compositions for different uses. A hard compact composition is used for making polishing wheels, while a softer, less dense material is needed for gaskets. Suitable compositions are prepared for every type of industrial application.



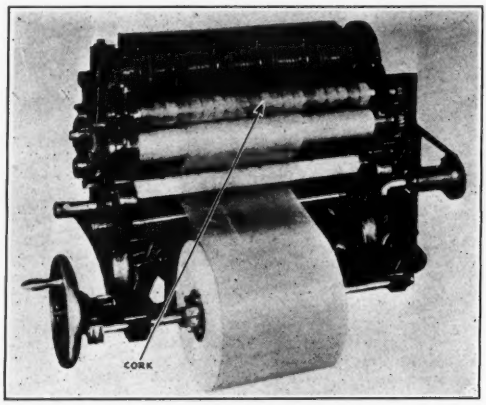
GASKETS FROM CORK COMPOSITION

Cork composition has the properties of natural cork with the advantage that it can be obtained in any desired size and form. And in addition, like so many synthetic products, it is preferable to the natural article for certain uses. The industrial applications of cork composition are wide and varied.



CORK GASKETS ARE USED TO SEAL METERS WHICH MEASURE THE FLOW OF GASOLINE

Cork composition is oil-resistant and this property has made it essential in the automobile industry and wherever oil-sealing gaskets are needed. Gaskets of any desired size and shape are cut from sheets of cork composition by dies. There may be as many as forty different gaskets on a single automobile. Cork-composition gaskets are used to prevent oil leakage in electric valve-grind-



A GUM WRAPPING MACHINE

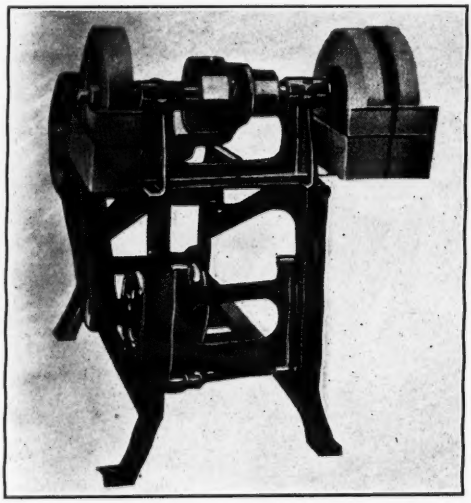
The top roll is covered with cork composition. It feeds and measures the paper.

ing machines, in the atomizers which spray oil into oil burners, in the wringer shafts of washing machines, on door checks, and in numerous other mechanical devices where oil-sealing is essential. Cork gaskets are also used in transformers to keep out moisture and in electric motors to keep out dust.

Cork composition is soft and resilient and it is used in many ways to absorb shock and reduce vibration. Mirrors are cushioned in their frames with cork composition, railway passenger cars have cork composition pads between the bodies and journal boxes to absorb vibration and reduce noise, and automobile bodies are cushioned in many places with strips of cork composition. Because of light weight, as well as resiliency, inner soles for shoes are made of cork composition. It is also used for a bottom filler in shoes.

The high coefficient of friction which cork possesses is responsible for many important uses of cork composition. Pulleys are faced with cork composition to prevent slipping of the rope, and for certain purposes they are made entirely of it.

The frictional property of cork and the durability of the composition make it a valuable material in processing of yarns and



CORK COMPOSITION WHEELS FOR POLISHING PLATE GLASS

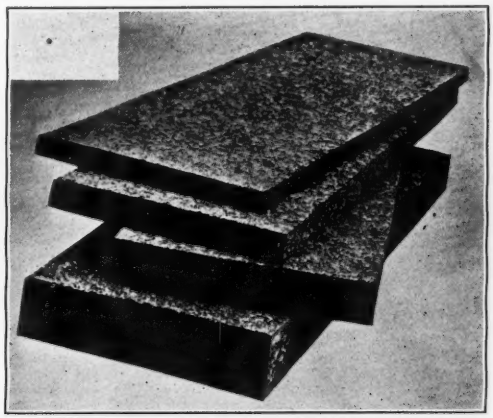
fabrics. Cork composition is used as a covering for spinning and drawing rolls in all kinds of textile mills.

Feed rolls are covered with cork composition and are used in wrapping, packaging, and measuring machines.

Wheels of cork composition are used to polish cut glass, mirrors, and tool handles. Some of these wheels are as large as three feet in diameter, while much smaller wheels are used to bevel pocket mirrors. Sometimes an abrasive is incorporated in the cork composition and this type of wheel is used for grinding.

Crown seals for beverages are made from cork composition as well as from natural cork. The soft, compressible properties of cork make it an ideal material for producing a tight seal. Cork composition is waterproof and is unaffected by the constituents of soft drinks. Certain bottled beverages are pasteurized and the cork composition is made to withstand this treatment.

There are many other useful and valuable applications of cork composition too numerous to mention here. One may be conservative and say that the daily life of the average person is affected in many ways by cork composition.

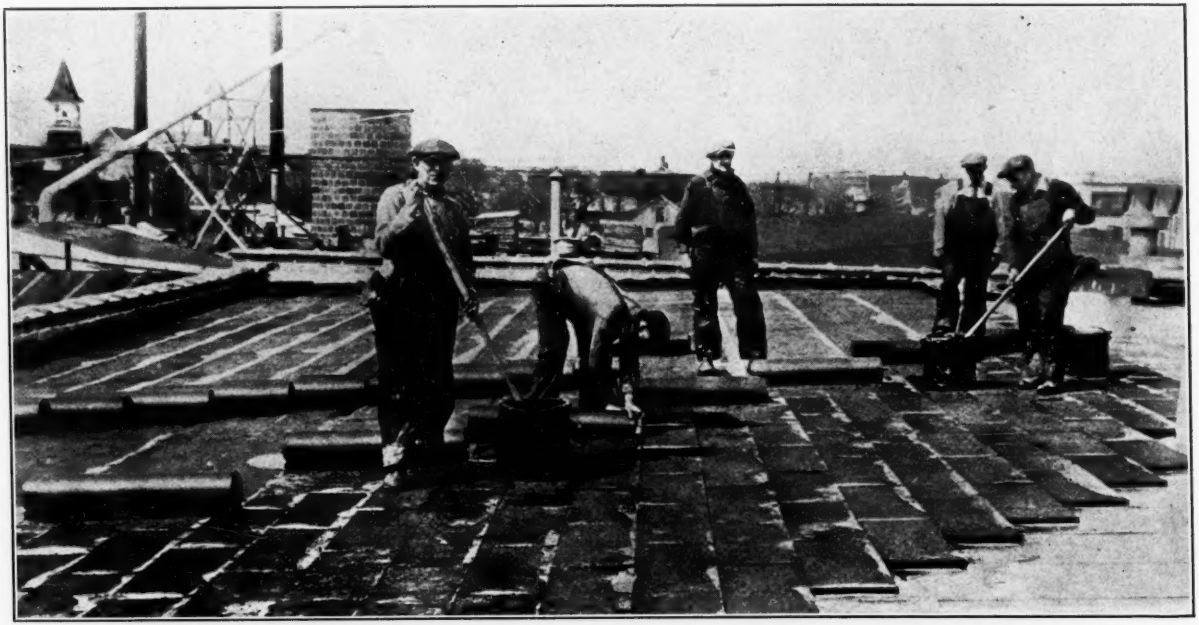


CORKBOARD FOR INSULATION

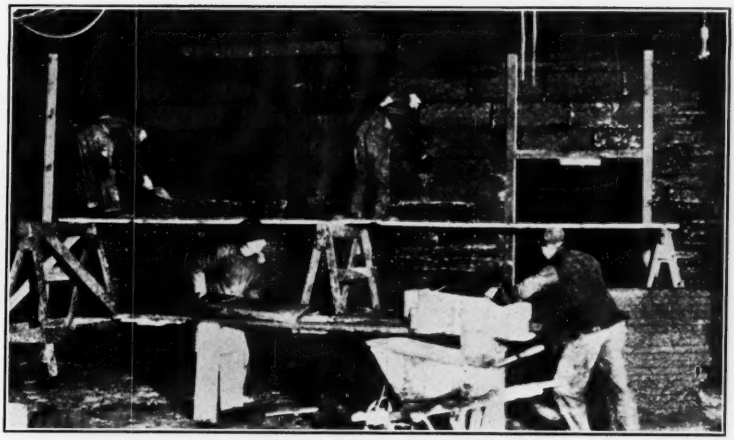
Corkboard

The low thermal conductivity of cork makes it a valuable material for low-temperature insulation. About fifty per cent of the cork imported in this country goes into the manufacture of corkboard. One factory alone uses 800,000 pounds of cork per week in the production of cork insulation board.

The pieces of cork bark are removed from the bales and placed on belt conveyors which carry them to the breaker. Here the cork is broken into small pieces and then by means of a fan conveyor it is carried to a grinder. From here the cork emerges through a screen which regulates the size of the particles. The cork passes next through large driers to reduce the moisture content. In the grinding process some of the cork is of necessity ground too fine. After drying, this fine cork and dust are separated by air flotation.



Laying Corkboard Insulation in Asphalt on the Roof of a Factory Building



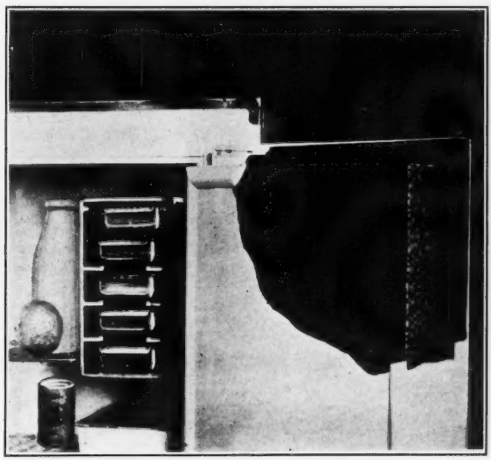
INSTALLING CORKBOARD IN A COLD STORAGE ROOM

Suction pipes then convey the cork particles to large bins where it is ready for use.

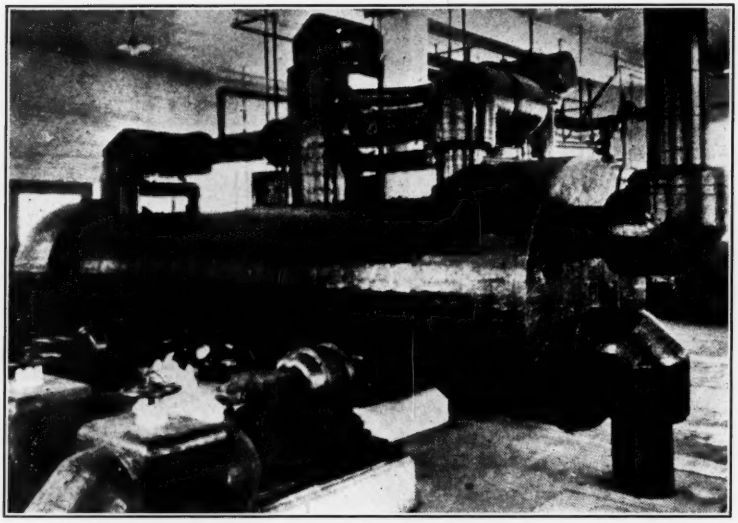
Corkboard may be made by several processes which depend upon the fact that cork expands when heated.

The cork is partially expanded first, then pressed together, and further expanded and baked. The cork particles pass from the storage bin to the expander, a smaller bin heated by steam. The steam passes into the pores of the cork and softens it during the expanding. From here the cork is run into cast iron molds. The molds are placed on a conveyor and slowly pass through ovens where the cork is baked.

Corkboard may also be manufactured by allowing the cork to pass directly from the storage bin into the mold and then expanding the cork with live steam.



CORKBOARD IN AN ELECTRIC REFRIGERATOR



COLD PIPES COVERED WITH CORK PIPE INSULATION

When corkboard is taken from the molds it is trimmed and sawed into the desired thickness.

Careful examination of a piece of corkboard shows how the particles have interlocked in the compressing and expanding operations. It is this interlocking of the pieces of cork that holds the particles in a single mass and gives tensile strength to corkboard.

The expanding of cork makes corkboard extremely light. Air-filled cells give to corkboard its extremely high insulating value. The heating necessary to make corkboard does not destroy the valuable properties of the natural cork. Corkboard is soft, resilient, and resistant to water and chemical action.

Because of these properties corkboard is widely used for insulating cold storage buildings, public buildings, factories, and private homes.

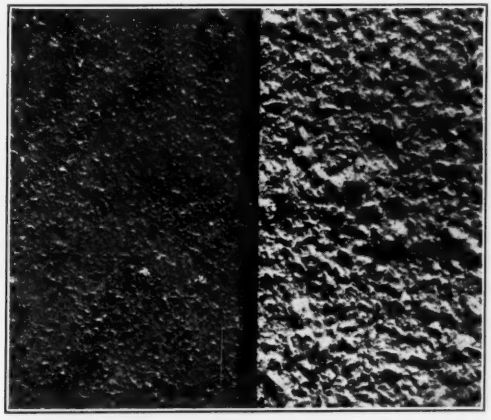
Cork is also used as an insulating material for cold pipes carrying ammonia, brine, or ice-cold drinking water. The cork covering is similar to corkboard. Granulated cork is compressed and baked in molds of necessary shapes and sizes to cover standard pipes and fittings. Cork covering on pipes saves eighty-five per cent of the refrigeration which would be lost if insulation were not employed.

Some Other Cork Products

High-Temperature Insulating Brick. Cork also plays an important rôle in high-temperature insulation. Insulating brick manufactured from

clay, diatomaceous earth, and waste cork is a most efficient insulating material for furnaces and superheaters.

The method of manufacture is unique. When corkboard is sawed and trimmed a quantity of waste cork accumulates. This scrap is ground and mixed with clay, diatomaceous earth, and water, and the mixture when homogenous is pressed into bricks. The wet bricks are dried until the moisture content is fairly low. The bricks are then loaded on cars and are ready to be fired. Firing is accomplished in a long kiln. The first car is loaded with wood which is burned to heat the kiln. The bricks then slowly pass through the kiln and the temperature is high enough to cause the cork to burn slowly. The burning cork raises the temperature and it is necessary with certain types of brick to cool the kiln with steam. Firing requires from two to four days, during which time every particle of cork—even in the center of the bricks—is completely burned and the bricks are slowly cooled. When the cars emerge from the kiln, the bricks are sized and stored for shipment.



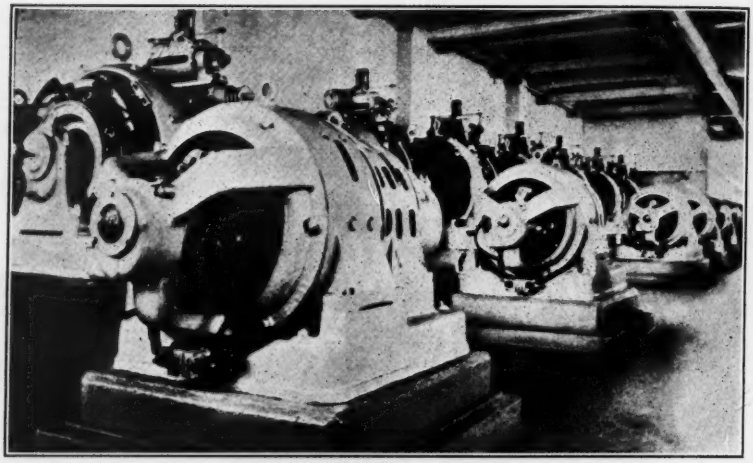
INSULATING BRICK FROM CORK IS POROUS AND LIGHT

On the right, insulating brick in which cork was used; on the left, a brick of the same composition, except for cork.

A good insulating brick must have high porosity, small pores, and low density. The burning of cork while the bricks are being fired gives porosity and since the burning is slow the pores are small. Bricks manufactured in this way are very light and have a low thermal conductivity. While the finished product contains no cork whatever, cork is essential in the manufacture of this light, porous type of insulating brick.

Machinery Isolation. Another use for granulated cork is in the manufacture of cork machinery isolation. Cork is pressed into a compact mass and baked. When taken from the mold it is cut into the desired size and thickness.

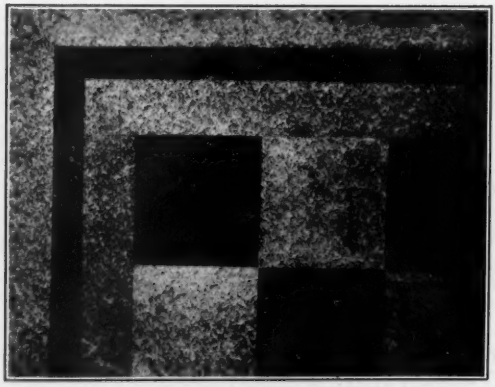
Cork machinery isolation is placed between the machinery and the foundation on which the machine rests or hangs. The cork isolates the machine from the floor, wall, or ceiling. The cushion of air-filled cells in



THESE GENERATORS ARE QUIET AND EFFICIENT
They rest upon cork machinery isolation.

the cork breaks up and absorbs vibration before it is transmitted and amplified through the foundation.

Linoleum. In 1863 Frederick Walton, an Englishman, noticed that linseed oil oxidized when spread in a thin layer over metal surfaces and became plastic and rubber-like in its properties. Walton took some oxidized oil, mixed it with cork, and rolled it out on a burlap backing. This new material was an excellent floor covering and Walton gave it the name linoleum. Previous to that time a floor covering had been manufactured from cork, rubber, and burlap. Linoleum quickly displaced this older product and the industry has grown until today there are linoleum floors in almost every country of the world.



SECTION OF A CORK TILE FLOOR

Cork used in linoleum manufacture must be of excellent quality and it is ground very fine. This finely ground cork has the properties of large

cork particles and adds toughness, resiliency, and durability to linoleum. Linoleum is manufactured plain and in a large variety of beautifully printed patterns and inlaid designs.

Other Cork Floors. Another cork floor is known as cork carpet. Granulated cork, binding material, and pigment are thoroughly mixed and then pressed onto a burlap back by a calendering process. Cork carpet is soft and resilient and makes an excellent floor material for churches, libraries, museums, and wherever freedom from noise is desired.

Cork tile is a floor material composed entirely of cork. It is made by compressing cork shavings under high pressure in molds and baking the cork. During the baking process the particles expand and interlock so that when cooled and removed from the molds the tile remains compressed. The temperature and time used in baking is varied so as to give different shades of color to the tile, ranging from light brown to dark brown. These different shades are utilized to give beautiful effects in laying cork tile floors.

Cork tile floors are very durable, are silent and resilient, and provide comfort and warmth not obtained in any other form of floor. Where work requires constant standing and walking during the day, the cork tile floors are ideal for they greatly reduce fatigue.

Cork brick is similar to cork tile in its properties and is manufactured as a floor material for dairies and buildings where live stock is kept. Cork brick is non-absorbent and is highly sanitary.

Looking Ahead

The cork industry is keenly awake to the importance of research and the benefits derived therefrom. Research is conducted on a broad and thorough basis, resulting in new and better products which are offered to the public every year. Manufacturing methods are improved and new industrial applications of cork are developed to meet the changing needs of other industries. In addition to development research, fundamental research is also carried on in the cork industry. Information obtained in this type of work has always proved very valuable and profitable. As more is learned about the properties and composition of cork and the materials used in the cork industry, new uses will be developed and the quality of products improved.

Cork, because of its unique physical properties and its chemical stability, is today the basis of a large and essential industry. The place of cork in the future will depend upon these same characteristic properties together with such information as research and time may discover. It is interesting to note that after two thousand years of uninterrupted use, cork is still today the ideal material for making bottle closures.

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BITTERSWEET

NOW that the tumult and the shouting have to some extent died away, a few teachers may have leisure and energy remaining to salvage a laugh or two from their bales of discarded examination papers. For some years past Dr. Ross A. Baker has collected choice "howlers" from chemistry examinations and the JOURNAL OF CHEMICAL EDUCATION has published some of them under the title, "Chemical Emanations."

Here are a few of Dr. Baker's latest finds: 1. Hydrogen is found in eclipses coming from the sun and stars. 2. Hydrogen may be prepared by the hydrolysis of water. 3. Hydrogen occurs every day in our life.

Such curios are humorous or pathetic, depending upon the point of view. We, ourselves, often manage to get a chuckle out of the more incongruous of them. Our opinion is that even a smile slightly seasoned with gall and vinegar is worth the ink and paper it costs.

However, these "howlers" occasionally have a lesson to teach us. We would hardly agree that they constitute a criticism of the teacher, but they sometimes do give an insight into some of the more obscure quirks of the high-school or freshman mind, and point the way to better methods of presentation.

At any rate, if you have found any good ones lately, please send them along to Dr. Baker or to us.

FARADAY'S CONTRIBUTIONS TO CHEMISTRY*

LYMAN C. NEWELL, BOSTON UNIVERSITY, BOSTON, MASSACHUSETTS

During the early years of his connection with the Royal Institution, Faraday worked almost exclusively in the field of chemistry and made several major contributions to this science. About 1830 and thereafter his investigations were mainly in electricity and magnetism, though he did some epochal work in electro-chemistry, liquefaction of gases, and colloids. He maintained an interest in chemistry throughout his long career. Many of his lectures were in chemistry. For over thirty years he was professor of chemistry in the Royal Institution.

. . . . . .

Faraday was engaged as an assistant in the chemical laboratory of the Royal Institution when a mere lad. He rose rapidly through various grades to professor of chemistry (1833), and retained this title for the rest of his long life. His contributions to chemistry began early in 1816 and continued without interruption to about 1830. The major contributions were "The Liquefaction of Gases," "The Isolation of Benzene and Butylene," "Preparation of Alloys of Steel," "Manufacture of Optical Glass," and "The Preparation of Several Organic Compounds Containing Chlorine." Among his later contributions we should include the second investigation of the liquefaction of gases and the investigation of the relation between electricity and chemical action which led to the law bearing his name and to the terms now in use to describe electrolysis.

Faraday's only book in chemistry was "Chemical Manipulations." However, two others have his name on the title page, viz., "Chemical History of a Candle" and "Experimental Researches."

For upward of ten years Faraday acted as a private assistant to Davy and a lecture assistant to both Davy and Brande. When Davy retired in 1825, Faraday practically assumed control of the chemistry at the Royal Institution. He at once plunged into chemical investigations long held in the leash and also established several lecture courses in chemistry which have continued to the present day. He himself delivered over one thousand lectures in chemistry during his career.

Faraday's engagement dates from March 1, 1813. He was to be paid 25s. a week, besides the use of two rooms in the house. His duties were in sharp contrast to his meager pay, and were specifically thus laid down by the managers:

> To attend and assist the lecturers and professors in preparing for, and during, lectures. Where any instruments or apparatus may be required, to attend to their careful removal from the model room and laboratory to the lecture-room, and to clean and replace them after being used, reporting to the managers such accidents as shall require repair, a constant diary being kept by him for that purpose. That one day in each

* Read before the Division of History of Chemistry at the 81st meeting of the American Chemical Society, Indianapolis, Indiana, March 30 to April 3, 1931.

FARADAY AS HE APPEARED DURING THE EARLY YEARS OF HIS CONNECTION WITH THE ROYAL INSTITUTION

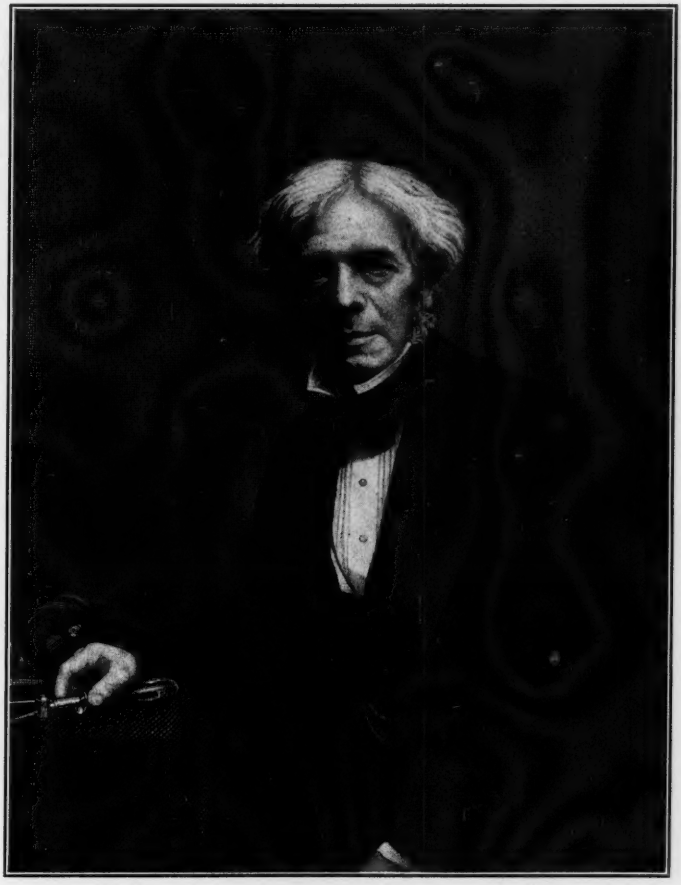
week he be employed in keeping clean the models in the repository, and that all the instruments in the glass cases be cleaned and dusted at least once within a month.

In addition to this array of tasks, he was also to serve as Davy's private assistant. And thus began the scientific career of Michael Faraday at the Royal Institution where he was to achieve brilliant success during the ensuing half century.

Scarcely settled in his new position, he not only utilized all opportunities for improvement at the Royal Institution but also established definite relations with the City Philosophical Society, a small group of young men who met weekly for mutual improvement. These privileges were soon interrupted, because seven months after his appointment, he accepted Davy's invitation to travel as his assistant on the continent. Although this tour was made under trying circumstances, due mainly to the overbearing attitude of Lady Davy, the scientific experiences gave Faraday a fresh impulse to study chemistry and to extend his knowledge of men and things. Friendships with de la Rive (father and son) and other scientists made on this tour were continued to Faraday's advantage for many years.

Returning to London in 1815, his appointment at the Royal Institution was renewed, and he was promoted to a higher and more responsible position. It is significant that in September, 1815, the handwriting in the laboratory notebook of the Institution changed from the large running letters of Brande to the small neat handwriting of Faraday.

Faraday, like many youths of his period, kept a commonplace book. He had an inborn passion for keeping notes of all kinds. Perhaps this tendency was accentuated by his early association with books and bookbinding. Be



FARADAY IN LATER LIFE

that as it may, it is a fact that Faraday took and preserved notes from the days when as a youth he listened to the lectures of Davy until the infirmities of old age compelled him to lay aside his pen. Faraday's earliest commonplace books are a mine of information about his interest in chemistry. Though the records in these books are not fully available, I have culled some items from various sources. The entries are more than mere records or questions. Many suggest a line of investigation. Some are marked "answered," or "made out." Others are hints which were doubtless incorporated into his work without further comment. I cite only a few of the items recorded soon after Faraday resumed his work upon the return in 1815 from the uncomfortable journey with Davy on the continent. These items (titles abbreviated) indicate that at this early date Faraday was thinking widely and wisely about chemistry:

Tests for baryta, strontia, and lime. Made out.
Sulphur and red lead.
Phosphorus and nitrate of silver and nitrate of ammonia.
Light on peroxide of zinc.
Distillation of oxalate of ammonia.
Action of silver oxide, chloride, fluoride, and bromide on ammonia, and nature of compound formed.
Production of chloride of calcium and ammonia.
Chromium compounds.
Silvering of silk and other animal substances.
Phosphoret of carbon.
Arsenic acid as a test for zinc.
Test to distinguish barytes from strontia.
Muriate of silver and ammonia.
Tellurium on sulphur.
Chlorine and carbon.
Mutual action of muriate and nitrate of ammonia.

When these early notebooks of Faraday are available in full* we shall doubtless find in them indisputable evidence that Faraday was essentially a chemist, certainly in the decade from 1816 to 1826.

At this time (1815) Faraday was the assistant of both Brande and Davy, and his duties brought him into intimate relationship with both, especially with Davy who was working on the safety lamp. But Faraday was an assistant only in name. He had awakened, and was prepared to give as well as to absorb. Early in 1816 he delivered a lecture "On the General Properties of Matter"—his first scientific lecture—before the City Philosophical Society. Later in the year he published a paper "On the Analysis of Some Native Caustic Lime"—his first scientific paper—in the *Quarterly Journal of Science* (the official organ, at that time, of the Royal Institution). Neither contribution was very important to science, but each was inspiring

* See J. CHEM. EDUC., **8**, 1443 (July, 1931).

FARADAY ANNOUNCING A DISCOVERY TO HIS WIFE ON CHRISTMAS MORNING, 1821

to Faraday because they marked the beginning of a long series of lectures and papers which place him high among the makers of chemistry.

About this time Davy began to relinquish active experimental work, and Brande slowly slipped into scientific insignificance. But Faraday forged rapidly ahead. His position in the Royal Institution was strengthened in 1820, again in 1821—the year of his marriage, and made secure in 1825, when, upon the recommendation of Davy, he was appointed Director of the Laboratories. At the same time he was relieved of some minor duties so that he could devote his time to research.

For about seven years Faraday had served as an assistant, but now his apprenticeship was over. He had won his freedom and could work untrammeled as his genius impelled. Moreover, he was encouraged to investigate and publish because early in 1824 he had been elected a Fellow of the Royal Society. Doubtless he felt that other learned societies would soon honor him, as indeed several did within a few years. During the preceding five years and within the following five, Faraday made fundamental contributions to chemistry; *e. g.*, the discovery of benzene (C_6H_6), the liquefaction of gases, optical glass, and alloys of steel. These will soon be discussed in detail. During this period he performed experiments in electricity and magnetism which culminated in 1831 in his epochal discovery that electricity can be derived from magnetism. In 1833 John Fuller, a member of the Royal Institution, founded the Fullerian Professorship of Chemistry and Faraday was appointed to this position for life. Thus within twenty years Faraday had risen from a menial position to the highest place in the Royal Institution. And it was during this double decade that Faraday made most of his contributions to chemistry.

Faraday's early contributions to chemistry were published in the *Quarterly Journal of Science*. Soon after the Royal Institution was launched, a journal was issued containing papers by members of the scientific staff and others. It will be recalled that part of Davy's long title was Assistant Editor of the Journals of the Institution. In a book issued by the Institution in 1802 (the earliest I have found) Davy's name appears on the title page as Joint Editor of the Journals together with Young's. But apparently a journal on a large scale and issued as the official organ of the Royal Institution did not appear until 1816. This is the *Quarterly Journal*, as it is usually called, and was continued until it was superseded by the *Proceedings of the Royal Institution*.

The early volumes of the Journal were nominally edited by William T. Brande, who was professor of chemistry at that time, though Faraday helped him and doubtless did much of the work; in fact at times, according to certain correspondence, he did all of the editing.

The *Quarterly Journal* contains many articles on chemistry by Faraday from 1816 to 1826. The first, as already stated, was the one on the analysis

of native caustic lime. This article is in Volume I and, strictly speaking, was "sent in" by Faraday and incorporated in a series of short communications by Davy. It is not included in the Table of Contents, though it is in the Index. However, it is credited to Mr. Faraday, Assistant in the Laboratory of the Royal Institution, and was supplemented by some "Observations" by Davy. Upward of thirty articles followed regularly during the next ten years, and with few exceptions they were on some chemical investigations conducted by Faraday. We cannot enumerate all these contributions. The following, however, should be cited (with abbreviated titles):

Escape of Gases through Capillary Tubes (two articles)
Solution of Silver in Ammonia
Sulphuret of Phosphorus
Combinations of Ammonia with Chlorides
On Sirium (two articles on a "New Element")
Gallic Acid and Tannin
Separation of Iron and Manganese
Analysis of Indian Steel
Decomposition of Chlorides by Silver, Hydrogen, and Zinc
Carburetted Hydrogen
Combustion of Diamond
Nitrous Oxide
Alloys of Steel
Carbon Chlorides
Change of Vegetable Colors
Hydrate of Chlorine
Action of Gunpowder on Lead
Liquefaction of Gases
Fluid Chlorine
Fumigation
Tests for Nitrogen (minute quantities)
Tubes for Storing Scarce Fluids
Crystals of Lead Chromate

Faraday's first long investigation was on alloys of steel. It was begun in 1820 in collaboration with a surgical instrument maker named Stodart, and was continued about two years. The primary object was to make modifications, or alloys, of steel suitable for surgical instruments, though the field widened as the work progressed. Faraday hoped a non-rusting alloy might be made by alloying steel with certain metals, *e. g.*, silver, platinum and its congeners, or nickel. But the nickel steel he made was found to be more readily oxidized than ordinary steel. The platinum steel, too, did not possess the desired properties. Silver steel proved more promising, though only a small percentage of silver could be incorporated in the alloy. The alloys of steel with iridium and rhodium were likewise disappointing.

The research as a whole was not profitable as far as the primary object was concerned. Only a few applications were the net result. Silver steel was used for a time by a manufacturer of fireplace fittings, and some of the other steels were made into razor blades, which were reported "to cut well." Faraday saved some of these blades and in later years would occasionally present a friend with a razor made from his own special steel—an alloy of steel and rhodium.

This research is sometimes referred to as "two years wasted." Faraday

may have been of this opinion at the conclusion of the work, because he wrote G. de la Rive thus:

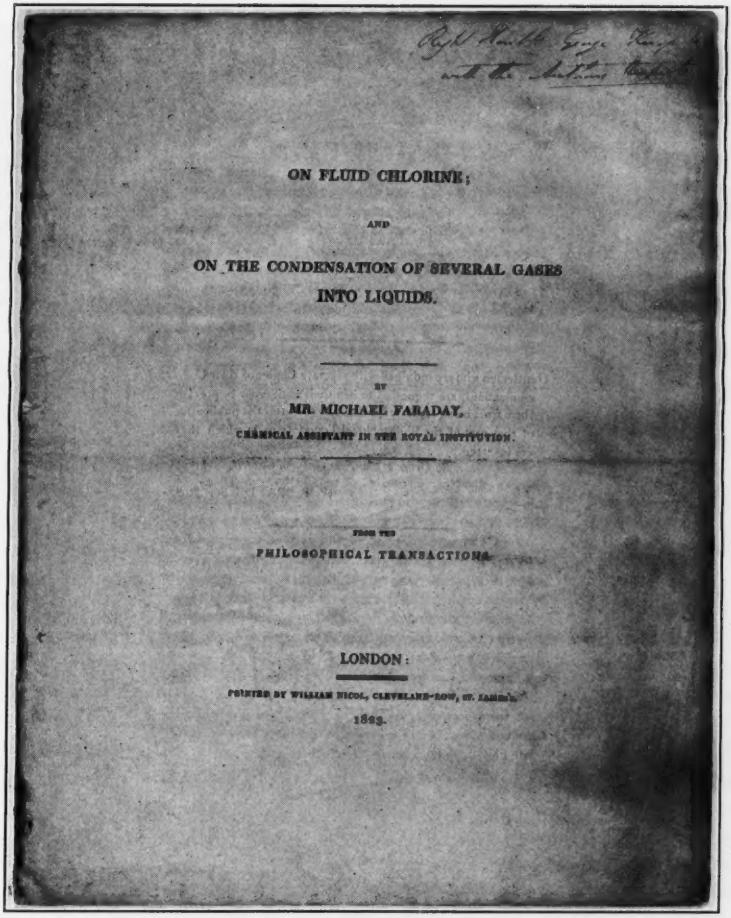
> Pray pity us that, after two years' experiments, we have got no further; but I am sure, if you knew the labour of the experiments, you would applaud us for our perseverance at least.

Looking back over this research and appraising it properly, we cannot agree that it was "two years wasted." Consider some of the positive results. First, Faraday demonstrated that small proportions of metals produce surprising effects in the properties of steel—now a fact of wide industrial application. Had other metals, *e. g.*, cobalt, tungsten, chromium, and molybdenum been available, Faraday would doubtless have anticipated the vast field of special steels and perhaps may have attained his primary object—a non-corrosive or stainless steel for use in surgical instruments, cutlery, and tools. Second, Faraday acquired skill as a manipulator and experience as an investigator. In 1820 he was still a beginner in many respects, and the discoveries during the next five years demonstrate unequivocally that during this intensive work on steel alloys Faraday learned how to plan and conduct a research. Hitherto he had been a promiscuous prober. Now he was an investigator seeking persistently the solution of large problems. Third, he discovered several facts about metals in the course of the investigation, *e. g.*, the easy volatilization of silver, the difficulty in reducing titanium compounds to the metal, the reticulated surface of an etched alloy of steel and aluminum, and many properties of alloys now commonplace but then unusual. Fourth, he learned a great deal about furnaces, crucibles, clays, and metals in general. So while we must concede that the research did not yield positive results to industry, we must conclude that the research was fruitful for Faraday by contributing factors which by assimilation helped him in his future investigations. Indeed, Faraday realized he had gained something intangible, because he slips this sentence into a paragraph toward the end of his descriptive letter to G. de la Rive:

> We are still encouraged to go on, and think that the experience we have gained will shorten our future labours.

During this work on steel alloys Faraday made a contribution to chemistry which is often overlooked, *viz.*, the formation of graphite from charcoal. Let us hear his own story (slightly condensed):

> Whilst making the carburet above mentioned [alloy of iron, aluminum, and carbon], we also succeeded in forming plumbago; but I am afraid this artificial production of it will not be very useful in its application. If iron be heated highly, and long enough, in contact with charcoal, plumbago is always formed. I have some buttons of metal here, weighing two or three ounces, that appear to be solid plumbago. The appearance, however, is deceitful, for it is only on the surface, and to the depth perhaps of $^1/_{40}$th of an



ON FLUID CHLORINE;

AND

ON THE CONDENSATION OF SEVERAL GASES
INTO LIQUIDS.

BY

MR. MICHAEL FARADAY,

CHEMICAL ASSISTANT IN THE ROYAL INSTITUTION.

FROM THE

PHILOSOPHICAL TRANSACTIONS.

LONDON:

PRINTED BY WILLIAM NICOL, CLEVELAND-ROW, ST. JAMES'S.

1823.

TITLE PAGE OF A REPRINT OF FARADAY'S FIRST SERIES OF PAPERS ON THE LIQUEFACTION OF GASES

inch, that the plumbago has been formed. The internal part is composed of the crystalline carburet before mentioned. What is plumbago is very good, and marks excellently well; and though we have never yet been able to fuse powdered plumbago into a mass, yet I think, if it were required to form it in a compact state to work up into pencils, it might be done by imbedding plates of iron about $^1/_{20}$th of an inch thick in charcoal, and heating intensely for a long time. This we have not yet had time to try, but intend to do so.

The next systematic contribution to chemistry made by Faraday was on the liquefaction of chlorine and several other gases. His account of this work was embodied in two papers—"On Fluid Chlorine" and on the "Condensation of Several Gases into Liquids"—which were read before the Royal Society in 1823 (p. 1501). It will be recalled that Davy had shown in 1810 that the substance hitherto called oxymuriatic acid was not a compound but a simple substance—and he gave the name chlorine to the element. Davy also showed that the solid prepared by Berthollet and called by him solid chlorine was really chlorine hydrate ($Cl_2 \cdot 8H_2O$). It was natural that Faraday who was closely associated with Davy should likewise be interested in chlorine, particularly in view of the hazy knowledge of the element. During his spare time Faraday did original work of his own choice. Probably his natural dislike of "doubtful knowledge" led him to re-examine chlorine hydrate. He analyzed it and the results were published in the *Quarterly Journal*. Davy, without stating the results he thought might follow, suggested that the hydrate be heated under pressure in a sealed glass tube. Faraday did so. As a result the tube became filled with a green-yellow gas, which on cooling separated into two liquids. Faraday found one to be water, and the other chlorine. Therefore what had happened was that the water and chlorine had separated, and the chlorine gas not being able to escape had condensed into the liquid form. To prove that the oily liquid was really chlorine and contained no water, Faraday put dried chlorine into a tube, cooled it to a low temperature, and obtained liquid chlorine. A curious—perhaps not entirely authentic—story is told about this research by Dr. Paris, a friend and biographer of Davy, who happened to visit the laboratory while Faraday was at work. Seeing the oily liquid in the tubes Dr. Paris scolded the young assistant for carelessness in using greasy apparatus. Later in the day when Faraday filed off the end of a tube, the contents suddenly exploded and the oily liquid completely disappeared. Faraday at once realized that the liquid had volatilized with violence when the tube was opened. So, early the next day Dr. Paris received the following laconic note:

Dear Sir:

The OIL you noticed yesterday turns out to be liquid chlorine.

Yours faithfully,

M. FARADAY

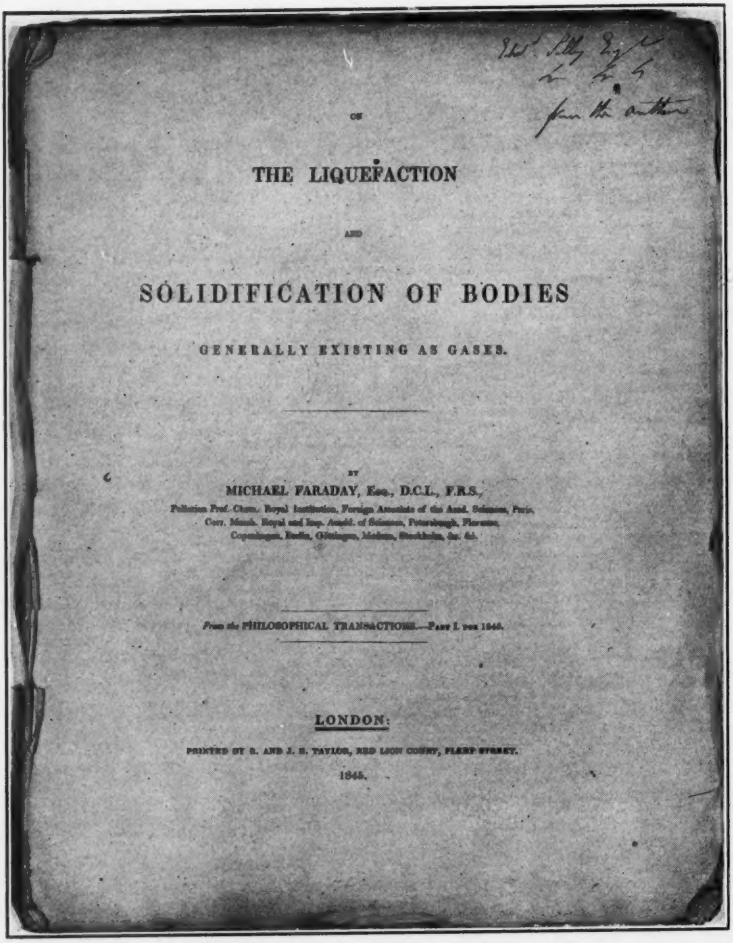
In a letter written March 24, 1823, to his friend G. de la Rive, Faraday concludes a lively story of his liquefaction of chlorine by these words—

> I hope to be able to reduce many other gases to the liquid form.

This hope was soon realized. Grasping the significance of the liquefaction of chlorine, Faraday continued this line of work and succeeded in liquefying sulfurous acid (SO_2), hydrogen sulfide (H_2S), carbon dioxide, euchlorine (a gas obtained from potassium chlorate and sulfuric acid), nitrous oxide (N_2O), cyanogen [$(CN)_2$], ammonia, and hydrochloric acid (HCl)—the last a repetition of Davy's experiment. In these experiments he used a simple and ingenious apparatus. He condensed the gas in a closed tube, bent at about a right angle, like the one he had used for chlorine. The end of the tube which contained the substance was heated while the other end was cooled. Besides showing the liquefaction of the gases, Faraday also determined a number of physical constants of the liquids. His attempts to liquefy hydrogen, oxygen, and some other gases were unsuccessful.

Soon after Faraday's paper was published his attention was called to the fact that his work on the liquefaction of gases had been anticipated. He at once (1824) admitted the priority of others in a frank article. It should be emphasized, however, that while isolated experiments on the liquefaction of gases were made by different chemists prior to Faraday's work, Faraday deserves credit for the first systematic work in this field. Furthermore, it should be noted that Faraday does not use the word "discoveries" in his article nor does he anywhere claim priority. He states that these experiments (after the one on chlorine) were continued at the request of Davy and were done under his general direction.

Faraday's first work on the liquefaction of gases was interrupted by an excessive number of experiments, lectures, and administrative duties, and it was not until 1845 that he published an account of a second series of experiments (p. 1504) (Alembic Club Reprints, No. 12). As in the early experiments, the gases were condensed by the simultaneous effects of high pressure and low temperature. But Faraday had become an expert manipulator during the interval, and the experiments were done with much skill, though the apparatus was still simple compared with the complicated, ponderous contrivances of other workers in this field. The pressure was obtained by two air pumps, though in certain cases he utilized the pressure exerted by the gases when generated in closed, strong, glass vessels. The low temperature was produced by allowing Thilorier's mixture of carbon dioxide and ether to evaporate under reduced pressure. By these devices he could obtain a pressure as high as fifty atmospheres and a temperature as low as $-166°$F. The gases were condensed in tubes (see page 1505) made of green bottle glass, from $^1/_6$th to $^1/_4$th of an inch in external diameter, and from $^1/_{32}$nd to $^1/_{30}$th of an inch in thickness. He says:



ON

THE LIQUEFACTION

AND

SOLIDIFICATION OF BODIES

GENERALLY EXISTING AS GASES.

BY

MICHAEL FARADAY, Esq., D.C.L., F.R.S.,

Fullerian Prof. Chem. Royal Institution, Foreign Associate of the Acad. Sciences, Paris, Corr. Memb. Royal and Imp. Acads. of Sciences, Petersburgh, Florence, Copenhagen, Berlin, Göttingen, Modena, Stockholm, &c. &c.

From the PHILOSOPHICAL TRANSACTIONS.—PART I. FOR 1845.

LONDON:

PRINTED BY R. AND J. E. TAYLOR, RED LION COURT, FLEET STREET.

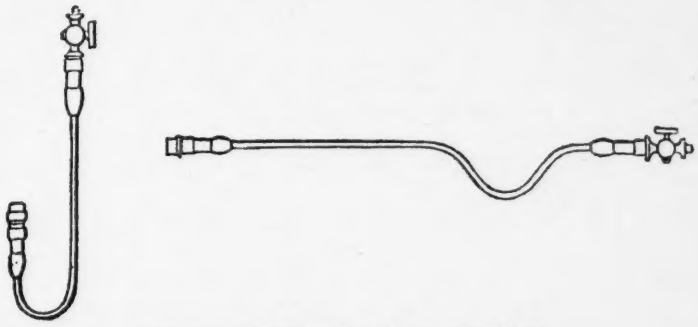
1845.

TITLE PAGE OF A REPRINT OF FARADAY'S SECOND SERIES OF PAPERS ON THE LIQUEFACTION AND SOLIDIFICATION OF GASES

They were chiefly of two kinds, about eleven and nine inches in length; the one, when horizontal, having a curve downward near one end to dip into the cold bath, and the other, being in form like an inverted siphon, could have the bend cooled in the same manner when necessary. Into the straight part of the horizontal tube, and the longest leg of the siphon tube, pressure gauges were introduced when required.

Caps, stopcocks, and connecting pieces were employed to attach the glass tubes to the pumps, and these, being of brass, were of the usual character of those employed for operations with gas, except that they were small and carefully made.

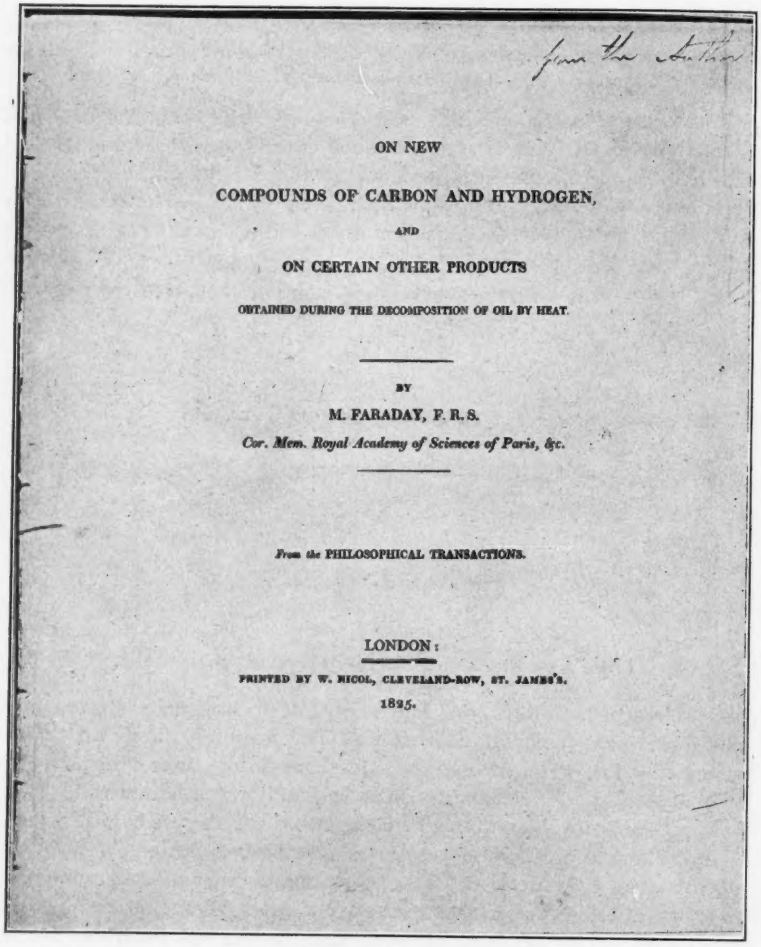
With this apparatus and by this method, which proved very effectual, Faraday obtained these results: olefiant gas—liquefied; hydriodic acid and hydrobromic acid—liquefied and solidified; fluosilicon—liquefied; phosphine, arsine, fluoboron—liquefied; muriatic acid—liquefied; sulfur dioxide and carbon dioxide—liquefied and solidified; euchlorine, hydrogen sulfide, ammonia, cyanogen, and nitrous oxide—liquefied and solidified. He could not solidify (at a temperature of $-166°$F.) chlorine, ether, alcohol, and carbon disulfide, nor liquefy hydrogen, oxygen, nitrogen, nitric oxide, carbon monoxide, and coal gas. He definitely predicted that at sufficiently low temperatures the latter group of gases—the so-called "permanent" gases—would pass into the liquid and solid states.



TUBES IN WHICH FARADAY LIQUEFIED GASES

Many elaborate observations were made, and Faraday with that keenness characteristic of a genuine investigator actually anticipated the results of later workers on critical constants by stating in substance that unless a given gas is below a certain temperature, it is not likely that any increase in pressure, except perhaps one exceedingly great, would convert the gas into a liquid. Furthermore he ascribes his failure to liquefy hydrogen to the fact that the $-110°$F. he reached "is probably above this point of temperature for hydrogen."

The next conspicuous work of Faraday resulted in the discovery of the two hydrocarbons, benzene (C_6H_6), and butylene (C_4H_6) *o*- and *p*-dichlorobenzene, nitrobenzene, and chlorine derivatives of butylene. This



from the Author

ON NEW

COMPOUNDS OF CARBON AND HYDROGEN,

AND

ON CERTAIN OTHER PRODUCTS

OBTAINED DURING THE DECOMPOSITION OF OIL BY HEAT.

BY

M. FARADAY, F.R.S.

Cor. Mem. Royal Academy of Sciences of Paris, &c.

From the PHILOSOPHICAL TRANSACTIONS.

LONDON:

PRINTED BY W. NICOL, CLEVELAND-ROW, ST. JAMES'S.

1825.

TITLE PAGE OF A REPRINT OF FARADAY'S PAPER DESCRIBING THE DISCOVERY OF BENZENE

composite discovery was described in a paper read by Faraday on June 16, 1825, at a meeting of the Royal Society (p. 1506).

The raw material from which Faraday separated benzene was an oil obtained as a by-product in the manufacture of an illuminating gas by the destructive distillation of fish oil. Several years prior to 1825 the Portable Gas Company of London manufactured this illuminating gas by dropping whale, or cod, oil into a hot furnace, subjecting the gaseous product to a pressure of about thirty atmospheres, and storing the purified gas in portable vessels for use in public buildings and private houses. During the compression an oily liquid was deposited. It was from this liquid that Faraday obtained benzene and butylene.

He soon found that this oil was a mixture, and decided to subject it to fractional distillation. Thus he says:

> With the hope of separating some distinct substances from this evident mixture, a quantity of it was distilled, and the vapours condensed at a temperature of 0° into separate portions, the receiver being changed with each rise of 10° in the retort and the liquid retained in a state of incipient ebullition. In this way a succession of products was obtained; but they were by no means constant; for the portions, for instance, which came over when the fluid was boiling from 160° to 170°, when redistilled, began to boil at 130°, and a part remained which did not rise under 200°. By repeatedly rectifying all these portions, and adding similar products together, I was able to diminish these differences of temperature, and at last bring them more nearly to resemble a series of substances of different volatility.

The next step is significant. Continuing, he says:

> During these operations I had occasion to remark, that the boiling point was more constant at, or between, 176° and 190° than at any other temperature; large quantities of fluid distilling over without any change in the degree; whilst in other parts of the series it was constantly rising. This induced me to search in the products obtained between these points for some definite substance, and I ultimately succeeded in separating a new compound of carbon and hydrogen, which I may by anticipation distinguish as bi-carburet of hydrogen.

If we substitute for "bi-carburet of hydrogen" the modern term, benzene (introduced by Laurent in 1834), we have in this last sentence the first words announcing the discovery of this fundamental compound.

Faraday separated his bi-carburet of hydrogen by freezing it out from the fraction boiling at 176–190°F. Next he found the physical constants, and the values he obtained are remarkably close to those accepted today. The account of his study of the chemical properties is impressive.

He noted that it burns with a bright flame and much smoke, forms an explosive mixture with oxygen, gradually deposits carbon, and yields carbureted hydrogen gas when passed through a red-hot tube, and is inactive toward iodine, potassium, and alkalies.

A specimen of the benzene prepared by Faraday is preserved in the museum of the Royal Institution.

Regarding the action with chlorine, he says:

> Chlorine introduced to the substance in a retort exerted but little action until placed in sunlight, when dense fumes were formed without the evolution of much heat; and ultimately much muriatic acid was produced, and two other substances, one a solid crystalline body, the other a dense thick fluid. It was found by further examination, that neither of these was soluble in water; that both were soluble in alcohol—the liquid readily, the solid with more difficulty.

The solid was undoubtedly *p*-dichlorobenzene and the liquid the ortho-isomer, but he did not examine them, merely saying, "I reserve the consideration of these, and of similar compounds, to another opportunity." In this connection we should not overlook the fact that as early as 1821 Faraday had described and analyzed a compound of carbon and chlorine which was subsequently shown by Hugo Müller to be hexachlorobenzene (C_6Cl_6); that is, by a curious reversion Faraday had in his hands, so to speak, a chlorine derivative of benzene four years before he discovered benzene itself or studied the action of the two reactants upon each other.

Regarding the action with nitric acid and sulfuric acid, he says:

> Nitric acid acted slowly upon the substance and became red, the fluid remaining colourless. When cooled to 32°, the substance became solid and of a fine red colour, which disappeared upon fusion. The odour of the substance with the acid was exceedingly like that of almonds, and it is probable that hydrocyanic acid was formed. When washed with water, it appeared to have undergone little or no change.
>
> Sulphuric acid added to it over mercury exerted a moderate action upon it, little or no heat was evolved, no blackening took place, no sulphurous acid was formed; but the acid became of a light yellow colour, and a portion of a clear colourless fluid floated, which appeared to be a product of the action. When separated, it was found to be bright and clear, but not affected by water or more sulphuric acid, solidifying at about 34°, and being then white, crystalline, and dendritical. The substance was lighter than water, soluble in alcohol, the solution being precipitated by a small quantity of water, but becoming clear by great excess.

The mono-nitrobenzene was not studied in detail, but the action with sulfuric acid excited Faraday's interest and was subsequently investigated.

He determined the composition of the bi-carburet of hydrogen by passing the vapor over copper oxide and also by detonating a mixture of the vapor and oxygen. The results of the two methods were concordant and from them Faraday concluded the substance was a binary compound containing "two proportionals of carbon and one of hydrogen." This conclusion led Faraday to call the compound bi-carburet of hydrogen and give it the formula C_2H. But these are not benzene and C_6H_6! The name benzene, as already stated, was not introduced until 1834. At the time Faraday made his discovery (1825) the proportional weight assigned to carbon was approximately 6. If the proportional weight of carbon had been 12 (as it is now) Faraday would have expressed his result as one proportional weight each of

carbon and hydrogen, and the formula would have been CH, *i. e.*, what we now designate as the simplest formula. In 1825 the whole subject of atoms and molecules, as well as the relation of atomic weights to molecular weights, was obscure, indeed molecular formulas were unknown. Hence Faraday did not understand the significance of the value 39 he obtained for the vapor density. If he had, he would have written the molecular formula. Translated into modern terms, the value of the specific gravity obtained by Faraday—39 to hydrogen 1—becomes 78 on the H_2 basis, and his simplest formula CH gives the molecular formula C_6H_6.

The second hydrocarbon obtained from the oil was called a "new carburet of hydrogen." He isolated it by heating the oil gently and passing the vapor through a tube cooled to 0° F. As before, he studied the properties and obtained results in agreement with modern observations. The properties differed from those of his bi-carburet of hydrogen, particularly the specific gravity which was between 27 and 28, as compared with 39 for the bi-carburet. He also found the composition by the detonation method to be four proportionals each of carbon and hydrogen. The result, according to Faraday, would give the specific gravity 28 [*i. e.*, $(4 \times 6) + (4 \times 1] = 28$], which agreed with his experimental value, and the formula C_4H_4. As in the analogous case of benzene, Faraday's formula becomes C_2H_4 according to analysis and C_4H_8 according to its vapor density [*i. e.*, $(4 \times 12) + (8 \times 1) = 2 \times 28 = 56$].

Going back just a little, we note that Faraday was astonished by the facts that his new carburet of hydrogen, **I**, contained carbon and hydrogen in the same proportion as olefiant gas (CH_2, old formula, and C_2H_4, new formula), but **II** had twice its density. He studied the action of chlorine on the new carburet and found that, like olefiant gas, it combined with an equal volume of chlorine and produced a compound of carbon, hydrogen, and chlorine different from the corresponding compound obtained from olefiant gas. He says,

> This is a remarkable circumstance and assists in showing that though the elements are the same, and in the same proportions as in olefiant gas, they are in a very different state of combination.

Faraday sagely remarks toward the end of his paper:

> In reference to the existence of bodies composed of the same elements and in the same proportions, but differing in their qualities, it may be observed that now we are taught to look for them, they will probably multiply upon us.

In 1824 Faraday was placed on a committee appointed by the Royal Society to improve the glass used for optical instruments, especially telescopes. Within a year the actual work of investigation was assigned to a subcommittee of three, Faraday, Dollond (the optician and instrument maker), and Herschel (afterward Sir John). Faraday was entrusted with the

chemical part, including the experimental manufacture of the glass, Dollond with the grinding of the lenses, and Herschel with the examination of the physical properties of the finished product.

Faraday attacked the problem with zeal. After preliminary experiments, furnaces were built in a special room at the Royal Institution and an assistant was hired to "keep the furnaces always at the same heat." The goal was a "heavy glass"—a lead boro-silicate, and the arduous attempt to make a better optical glass of this type was conducted for five years. In 1829 the results were communicated by Faraday to the Royal Society in his Bakerian lecture of that year—a long memoir which took three sittings for its delivery.

In 1830 the experiments on glass-making were stopped. The next year the larger Committee reported to the Council of the Royal Society that the telescope made of Faraday's glass

> . . . .bears as great a power as can reasonably be expected, and is very achromatic. The Committee therefore recommend that Mr. Faraday be requested to make a perfect piece of glass of the largest size that his present apparatus will admit, and also to teach some person to manufacture the glass for general sale.

Faraday declined in respectful terms to continue the work.

The research on optical glass was a failure, as far as it concerned the original hope of improvements in telescopes. Nevertheless the glass was used in spectroscopes and microscopes and provided Faraday with a glass which subsequently became indispensable in his diamagnetic and magneto-optical researches.

In his paper "On the Mutual Action of Sulphuric Acid and Naphthaline," read before the Royal Society, February 16, 1826, and published in the *Philosophical Transactions* of the same year, Faraday gives a detailed account of his discovery of "a new acid" and the preparation of fifteen of its salts (p. 1511). He named the acid "sulphonaphthalic" acid. As a matter of fact Faraday had actually prepared the two isomeric naphthalene mono-sulfonic acids, though he did not distinguish the isomers from each other.

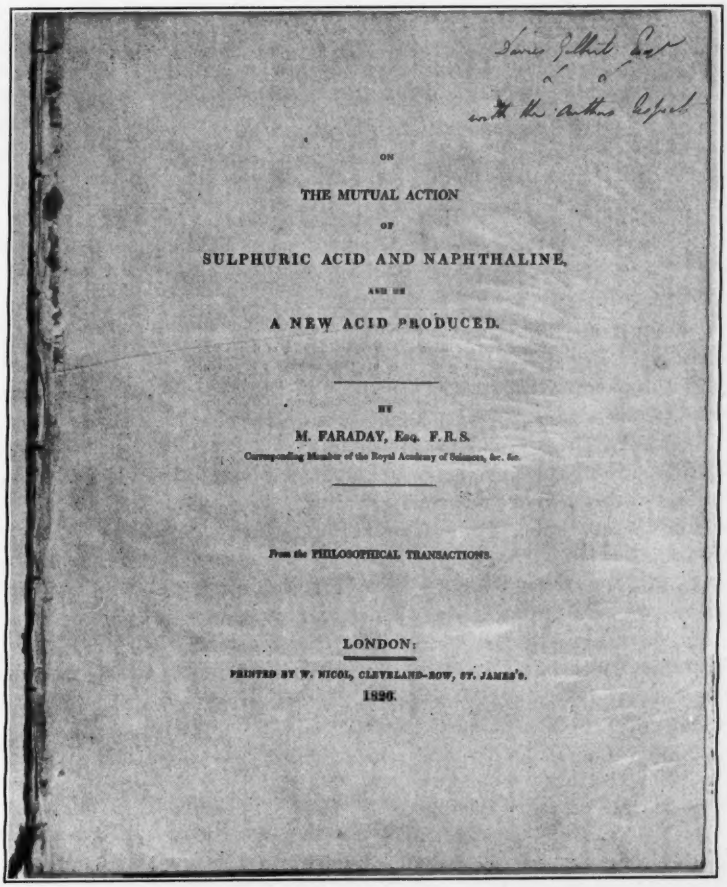
In his original paper he says:

> When concentrated sulphuric acid and naphthaline are brought into contact at common, or moderately elevated temperatures, a peculiar compound of sulphuric acid with the elements of naphthaline is produced, which has acid properties.

After purifying the "peculiar compound," studying its properties, and preparing its potassium salt, he says:

> It was now evident that an acid has been formed peculiar in its nature, and producing with bases peculiar salts.

He next prepared the barium salt and decomposed it by careful addition of sulfuric acid ("no excess of sulphuric acid being permitted") into barium



James Gilbert Esq
with the Author's Regard

ON

THE MUTUAL ACTION

OF

SULPHURIC ACID AND NAPHTHALINE,

AND ON

A NEW ACID PRODUCED.

BY

M. FARADAY, Esq. F.R.S.

Corresponding Member of the Royal Academy of Sciences, &c. &c.

From the PHILOSOPHICAL TRANSACTIONS.

LONDON:

PRINTED BY W. NICOL, CLEVELAND-ROW, ST. JAMES'S.

1826.

TITLE PAGE OF A REPRINT OF FARADAY'S PAPER IN WHICH THE DISCOVERY OF THE TWO ISOMERIC NAPHTHALENE MONO-SULFONIC ACIDS IS DESCRIBED

sulfate and a pure aqueous solution of the peculiar acid. Having isolated the acid, he proceeded to study its properties carefully—reaction with litmus, crystallization by slow evaporation and by dehydration over sulfuric acid *in vacuo*, taste, melting point, decomposition by heating, and then says:

> These facts establish the peculiarity of this acid, and distinguish it from all others.

From the acid he prepared fifteen salts—potassium, sodium, ammonium, barium, strontium, calcium, magnesium, iron, zinc, lead, manganese, copper, nickel, silver, and mercury. He gives a detailed statement of the properties of these salts. Finally he analyzed the acid and the barium salt, the latter being chosen because he says this salt:

> . . . .was found to be very constant in composition, could be obtained anhydrous at moderate temperatures, and yet sustained a high temperature before it suffered any change.

Faraday used the combining, or equivalent weights, accepted at that time (1825) and stated his results in "proportionals." Hence his figures are not easy to translate into the values used today. However, a critical examination of his analytical methods and arithmetical results made by my colleague, Dr. J. Philip Mason, shows that the analysis agrees with the composition of naphthalene mono-sulfonic acid, and proves that Faraday discovered this acid and many of its salts.

Faraday discovered several chlorides of carbon. In 1820 he isolated a compound which was undoubtedly hexachlorobenzene. The next year he published an article giving an account of the discovery of two chlorine derivatives of ethylene. By treating Dutch liquid (ethylene chloride, $C_2H_4Cl_2$) with chlorine in the sunlight, he obtained a white, crystalline substance, which he showed by analysis was a chloride of carbon free from hydrogen. This compound was obviously formed by replacing the hydrogen by chlorine, thus (in our formulas):

$$C_2H_4Cl_2 + 4Cl_2 = C_2Cl_6 + 4HCl$$

Faraday called this compound "perchloride of carbon." Later it was called "etherosic chloride" or "carbon sesquichloride." It is our hexachloroethane (C_2Cl_6). Shortly afterward, by passing the perchloride through a hot tube he obtained a liquid which he called "protochloride of carbon." It proved to be a compound of carbon and chlorine but in different proportions from the first one, and it also had a different specific gravity. In the first compound the proportionals of carbon to chlorine were 2 to 3 and in the second 1 to 1. These give in his formulation C_2Cl_3 and CCl. Translated into our formulas these become C_2Cl_6 and C_2Cl_4. The next year (1822) he published an account of an examination, jointly with Phillips, of a compound prepared by another chemist, in which it appeared that a third

chloride of carbon exists, having 2 proportionals of carbon and 1 of chlorine. In his formulation, the expression would be C_2Cl, which would become C_2Cl_2 in our formulation, though we cannot assign the correct molecular formula because of insufficient data.

In his account of the discovery of two new compounds of carbon and hydrogen published in 1825, he mentions the isolation of two chlorine derivatives of bi-carburet of hydrogen, which were undoubtedly *o*- and *p*-dichlorobenzene. Toward the end of the paper he states that chlorine combines with the new carburet of hydrogen, volume for volume. That is, butylene—our name for his new carburet of hydrogen—united with chlorine to form butylene dichloride, thus:

$$C_4H_8 + Cl_2 = C_4H_8Cl_2$$

Faraday did not name this chlorine compound.

While working on the chlorination of ethylene, Faraday discovered a new iodine compound. By treating olefiant gas with iodine in the sunlight, a white crystalline solid was obtained. He showed a little later that it contained 1 proportional of iodine and 2 of olefiant gas and concluded it was analogous to the compound of chlorine and olefiant gas. That is, in our nomenclature it would be $C_2H_4I_2$. He did not name this substance.

In appraising these discoveries of the halogen derivatives of hydrocarbons, we should remember the compounds were studied several years before accurate and reliable analytical methods were available and upward of forty years before atomic and molecular weights were clearly differentiated and understood. This work as a whole is indisputable evidence of Faraday's ability as a chemist.

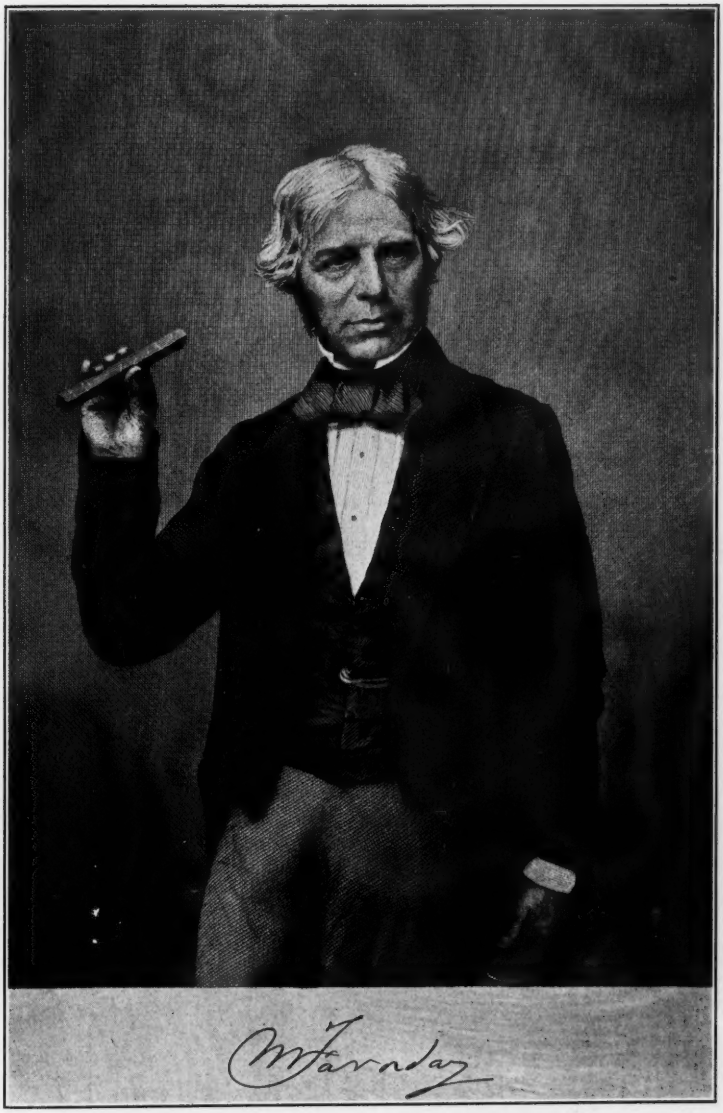
One of Faraday's major contributions to chemistry was the set of facts which led to the law bearing his name, the law connecting the amount of electricity involved in quantitative electrochemical changes. Faraday's first commonplace book indicates that he was interested in experimental electricity about the time he began to work at the Royal Institution, and his early notebooks reveal his profound grasp of the fundamental questions provoked about that time by the baffling field of electricity and magnetism. Moreover, he was the institutional heir to Davy's discoveries of the fundamental relation between current electricity and chemical change. The isolation of sodium and potassium from their bases by the action of a current from the big battery of the Royal Institution had been accomplished only ten years before on the very spot where Faraday worked and reflected. While it is a fact that from 1816 to 1826 his major field of interest was chemistry, it is likewise true that during this period he attacked the alluring field of electricity and magnetism. His early published articles on electricity are few but his notes are extensive. We find in his notebooks and letters many stray entries hinting at his eagerness to abandon the tedi-

ous, time-consuming researches on steel and glass in order to follow up promising experiments in magnetism and electricity. It is generally known that these experiments reached a peak in 1831, when Faraday discovered electromagnetic induction, and thereby made possible the invention of the induction coil and the electromagnetic machines that led to the invention of the modern dynamo. Let us consider this discovery briefly. An electric current is generated by moving a magnet into and out of a coil of wire. The crucial part of this discovery was recorded in his notebook as having been made on October 17, 1831, though he had been working several months on the problem. He then describes as follows the discovery of the production of electricity by the approximation (bringing near) of a magnet to a wire:

> A cylindrical bar magnet of an inch in diameter, and eight inches and a half in length, had one end just inserted into the end of the helix cylinder (220 feet long): then it was quickly thrust in to the whole length, and the galvanometer needle moved; then pulled out, and again the needle moved, but in the opposite direction. The effect was repeated every time the magnet was put in or out, and, therefore, a wave of electricity was so produced from mere approximation of a magnet, and not from its formation *in situ*.

From this time (1831) on to the end of his life Faraday continued his experiments on magnetism and electricity, thereby enriching science in numberless ways and contributing incalculably to the progress, comfort, and happiness of all peoples.

Faraday's contribution to chemistry alluded to above, *viz.*, that electrochemical decomposition is capable of mathematical formulation, has peculiar significance. Faraday was not a mathematician. He was an experimentalist. Results of countless experiments are recorded in his notebooks with scarcely an interpretive number. Hence this discovery, which is known as Faraday's law and has today its original validity, stands out in a striking way. Going back a little, we find that Faraday by 1832 had exploded the notion of different kinds of electricity—an unfortunate and misleading error inherited by him. That is, he showed by experiment the identity of electricity—static or galvanic—whatever the source. This work led him to investigate the conducting power of fused solids and then on to a closer study of electrochemical decomposition in general. In this larger field he entered into speculations about the nature of electricity and the mechanism of electrochemical decomposition. This digression was not a misfortune because he aroused the interest of his friend Whewell, who suggested the need of specific terms to express the facts, or at least to describe the apparatus and the process. Part of the correspondence between Faraday and Whewell on this matter has been lost, but two letters remain which show that Whewell proposed the terms, and that Faraday expressed his willingness to adopt them. The terms finally adopted by Faraday (May,

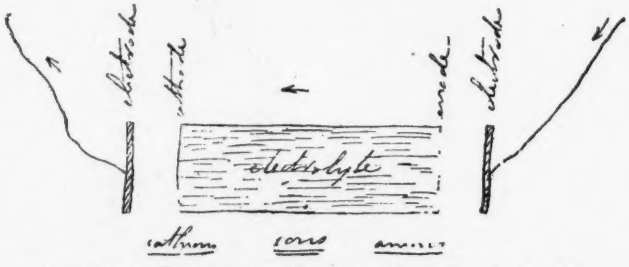


FARADAY LECTURING AT ONE OF THE CHRISTMAS LECTURES FOR CHILDREN

1834) were *electrode* for the old term pole, *anode* for the positive, and *cathode* for the negative pole, respectively, *ion* for the electrified particle, *anion* for the negative ion, and *cation* (also spelled cathion) for the positive ion. He also adopted the terms *electrolyte* for the decomposable substance and *electrolysis* for the decomposing process. Most of these terms are included in a sketch made by Faraday in his own bound volume of the *Experimental Researches* (see illustration below). These terms were not used slavishly by Faraday, lest he might be misled into ideas about an electric current which would hamper his conclusions.

His next step was to construct an instrument to measure the current and he finally perfected a form of electrolytic cell ever since known as a voltameter, a form "in which water is decomposed, the quantity of electricity which has flowed through it being measured by the quantity of the gas or gases evolved during the operation."

Having a reliable standard, Faraday next investigated "cases of decom-



SKETCH OF AN ELECTROLYTIC CELL FROM FARADAY'S NOTEBOOK

position by an electric current" as he called them. He conducted a long series of experiments in which many different substances were subjected to the action of a current. In these experiments he compared the quantities of the materials formed (as gases or deposits) with the quantities of hydrogen liberated in the standard voltameter. In all cases he found that these quantities were proportional to the numbers called at that time the equivalent weights of the substances. Thus, referring to the numbers and substances, he says:

> I have proposed to call the numbers representing the proportions in which they [the substances] are evolved *electro-chemical equivalents*. Thus, hydrogen, oxygen, chlorine, iodine, lead, tin are ions; the four former are anions, the two metals cations, and 1, 8, 36, 125, 104, 58 are their electro-chemical equivalents nearly.

It was hoped by Faraday's contemporaries that his method of determining electrochemical equivalents would solve the perplexing problem of choosing the correct atomic weights, but the hope was not realized owing to confusion in the use of the terms atom and molecule and especially to

ignorance of the number of atoms in the molecules of compounds. This difficulty was not cleared up until about 1860. This investigation also showed one other fact, viz., the quantity of electricity needed for the liberation of the electrochemical equivalents is independent of the time. Put into definite form—as Faraday's law—his results might be stated thus:

A definite weight of an element or a radical is liberated when a fixed quantity of electricity passes through a solution.

The definite weight is the equivalent weight of the element or the radical and the fixed quantity of electricity is the faraday (equal to 96,500 coulombs). This law is at the basis of the electrochemical industries which involve electrolysis. Hence it is a major contribution of Faraday to chemistry.

Toward the end of his life Faraday worked on colloidal gold. In 1856 he gave a lecture at the Royal Institution which included "some observations on finely divided gold." His Bakerian lecture of this same year was on "The Optical Properties of Precipitated Gold." He supplemented these two contributions by a third lecture in 1857.

Colloidal gold had been the subject of much chemical investigation. As early as 1802 J. B. Richter found and proved that it consisted of minute particles of metallic gold. This result was later independently demonstrated by Berzelius and Liebig. In his paper "On the Experimental Relations of Gold (and Other Metals) to Light" (*Phil. Trans.*, **1857,** p. 145), Faraday says:

> The latter [colloidal solutions of gold] have all the appearance of solutions. But they never are such, containing in fact no dissolved, but only diffused gold. The particles are easily rendered evident, by gathering the rays of the sun (or a lamp) into a cone by a lens, and sending the part of the cone near the focus into the fluid; the cone becomes visible, and though the illuminated particles cannot be distinguished because of their minuteness, yet the light they reflect is golden in character, and seems to be abundant in proportion to the quantity of solid gold present.
>
> The state of division of these particles must be extreme; they have not as yet been seen by any power of the microscope.
>
> I believe the purple of Cassius to be essentially finely divided gold, associated with more or less of oxide of tin.

Faraday was among the first, perhaps *the* first, to record the discovery of the protective action of gelatin. He showed that the addition of gelatin to his "gold solution" made it so stable that it was possible to evaporate portions to dryness without change in color. A specimen of Faraday's "gold solution" is preserved in the Royal Institution.

Faraday published only one book in chemistry, though his name appears on the title page of two others. In his commonplace book of 1820 there is an entry which shows he was contemplating the publication of a book on chemical manipulation. At this time Faraday realized keenly that success in experimental work was measured by manipulative skill. The entry includes the phrases "Lessons in Chemistry," "Processes for

FARADAY PERFORMING AN EXPERIMENT

Manipulation." This brief entry is the germ of a book which Faraday thought about for several years. In February and May, 1827, he gave a course of twelve lectures at the Royal Institution on "The Philosophy and Practice of Chemical Manipulation." Later in the year he published his book on "Chemical Manipulation." Faraday said in the preface:

> The object of this book is to facilitate to the young chemist the acquirement of manipulation, and, by consequence, his progress in the science itself. It does not attempt to inculcate the principles of the science, but the practice; neither does it claim to teach a habit of reasoning, but has solely in view the art of experimenting.

The book includes an inspiring treatment of these topics:

> The conveniences and requisities of a laboratory.
> General chemical apparatus and its uses.
> The methods of performing chemical operations.
> The facilities acquired by practice.
> The causes which make experiments fail or succeed.

This book was for many years an indispensable aid to chemists. A second edition appeared in 1830, and a third in 1842. He refused to bring out a later edition; although, somewhat obsolete, it would have continued to be helpful. It is today a mine of information about manipulation.

The second book referred to is Faraday's "Chemical History of a Candle," which will be discussed presently. The third is Faraday's "Experimental Researches." This is not a new book, being a collection of his papers published in various journals. The first of the large folio volumes starts in 1831 with paragraph 1, and goes on, through four volumes, to paragraph 15,997 in 1859. The three volumes on electricity were published in 1839, 1844, and 1855. The fourth volume, on chemistry and physics, which contains also the most important of his earlier papers, was published in 1859.

Faraday's salary at the Royal Institution was always meager, and at times he was induced to do commercial work, consulting, and expert advising. But he did not enjoy the work of a consulting chemist. The few public experiences he had as an expert witness were mortifying and distasteful. While he was willing to help in any way possible, he really avoided appearing in public as a chemist. His only extended service as a scientific advisor was given to Trinity House, a service which began in 1836 and lasted until 1865. He declined to accept a title and left the amount of remuneration to the authorities, saying

> . . . .the sum, therefore, of £200 is quite enough in itself, but not if it is to be the indicator of the character of the appointment. The position which I presume you would wish me to hold is analogous to that of a standing counsel.

Faraday retained this position for nearly thirty years and advised Trinity House on all chemical and other scientific suggestions and inventions connected with lighthouses or buoys—not for personal gain or renown but for the public good. In his own words "I am simply an advisor upon philosophical questions and am put into action only when called upon." It is pleasant to note that when Faraday relinquished this work the authorities of Trinity House continued to pay him £200 a year for the rest of his life.

A discussion of Faraday's contributions to chemistry should not be limited to the discovery and study of compounds. He was a superb lecturer and during forty years delivered hundreds of lectures, mainly in chemistry. Soon after his return (1815) from the continental tour with Davy, he re-

newed his association with the City Philosophical Society and frequently gave lectures at its meetings during the next two years (1816–18). These lectures were carefully prepared expositions of the properties of the elements and their important compounds, as well as of the general aspects of physical science. These series of lectures not only gave Faraday an excellent opportunity to extend his own knowledge of chemistry, acquire skill in manipulation before an audience, and improve ability to express his thoughts in good English, but it also opened wide the door of friendship which was never closed by Faraday throughout his long life. In his last lecture he says:

> I retire gratified by the considerations that every lecture has tended to draw closer the ties of friendship and good feeling between the members of the Society and myself.

In 1829 Faraday was appointed Lecturer in Chemistry at the Royal Naval Academy at Woolwich. Here he gave twenty lectures annually for twenty years. He went to the Academy once a week, and prepared his lecture and experiments in the afternoon or evening preceding his lecture, which was delivered early the following morning.

"No man was so respected, admired, and beloved as a teacher at the Military Academy in former days as Faraday." His main aim was to impart a taste for chemistry and give them as much information as youths of this type could assimilate.

He says in a letter to his successor:

> I was ever very kindly received there, and that proof of regard which one must ever feel in concluding a long engagement would be in some degree lessened with me by seeing that you had reason to be satisfied with your duties and their acceptance.

Faraday declined numerous requests for courses of lectures. Many of these had to be set aside in view of his extended duties at the Royal Institution. In passing it should be noted that in 1827 he declined the professorship of chemistry at London University (later University College and now a part of the University of London).

Faraday's lectures at the Royal Institution began in 1825 immediately after he was appointed to the responsible position of Director of the Laboratories. It will be recalled that Davy's lectures started shortly after his appointment in 1801 and continued till he was obliged to resign on account of ill health. Brande succeeded Davy as lecturer. Faraday was a lecture assistant to both Davy and Brande. Hence Faraday was thoroughly informed about the kind of lectures the audiences had heard, and doubtless he had seen ways in which lectures at the Royal Institution could be extended or modified in accordance with the plans of founders of the Institution. He surely must have given this matter careful thought because one of his first acts after his appointment as Director in 1825 was to initiate evening meetings of the members for the discussion of scientific subjects,

first in the laboratory and later in the lecture room. These meetings became so popular they were organized by Faraday into Friday evening lectures, which have been given ever since. He also originated the annual Christmas lectures for young people, fostered this feature, and made it into a delightful annual event. The first series (six lectures) was given by Faraday and his subject was "The Chemical History of a Candle." These lectures at Christmas time became very popular. Faraday gave nineteen series and many famous chemists have had the honor and pleasure of giving this holiday series. Faraday's first lectures on the candle were repeated by him several times, the last occasion being at Christmas, 1860, when he was an old man. These lectures had become so famous by that time, they were taken down in shorthand by the notable English chemist, William Crookes, who printed them in his journal, the *Chemical News*, and later edited them for publication (1861). "The Chemical History of a Candle" is a classic and is one of Faraday's important contributions to chemistry.

The various courses of lectures started at the Royal Institution by Faraday's predecessors were continued by him, improvements and extensions being made as the field of chemistry expanded. Many were delivered at regular times by Faraday—all of course in the theater, as it is called—and were official records of his investigations in chemistry and electricity or accounts of the progress in physical science. These lectures which were invariably prepared with care and liberally illustrated by experiments, frequently consumed an excessive amount of time at some critical stage of his investigations. But Faraday looked upon his lecturing as a solemn duty, a duty to contribute all he could to the progress of science in a precise, accurate, comprehensible way.

We have omitted many of Faraday's minor contributions to chemistry. In numerous cases these are woven into his major contributions or are an integral part of investigations not exclusively chemical. Enough has been recorded in this article, however, to show that Faraday's contributions to chemistry justify our claim that he was a chemist of the first rank.

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AN EXPERIMENT ILLUSTRATING THE LAW OF MASS ACTION

EDWARD M. GERSTENZANG, 1560 EAST THIRTY-SECOND STREET, BROOKLYN, NEW YORK

Chloramine-T in aqueous solution is in a state of equilibrium represented by the following equations.

$$CH_3C_6H_4SO_2NaNCl + H_2O \rightleftharpoons CH_3C_6H_4SO_2NH_2 + NaOCl \quad (1)$$

$$NaOCl + H_2O \rightleftharpoons NaOH + HOCl \quad (2)$$

Due to the formation of hypochlorite in its aqueous solution, chloramine-T liberates free iodine from a neutral solution of potassium iodide.

$$2I^- + ClO^- + H_2O \rightarrow Cl^- + 2OH^- + I_2\downarrow \quad (3)$$

As a result the solution becomes strongly alkaline since the reactions represented by equations (1) and (2) progress toward the right as a consequence of the decomposition of hypochlorite. Since free iodine is soluble in the presence of excess hydroxyl ion, most of the iodine is left in solution.

$$I_2 + 2OH^- \rightleftharpoons I^- + OI^- + H_2O \quad (4)$$

If the concentration of hydroxyl ion could be repressed, most of the iodine would precipitate. This effect is accomplished by means of ammonium acetate which removes hydroxyl ion from the field of reaction due to the formation of ammonium hydroxide.

The procedure for this experiment is as follows: Dissolve a small crystal of potassium iodide in 25 cc. of water. Add about ten drops of a 5% solution of chloramine-T. The solution will remain colorless or acquire a faint yellowish tinge. Now add several grams of ammonium acetate. The solution takes on a cherry color.

This experiment illustrates the effect of removing or diminishing one of the reactants (hydroxyl ion) from a system in equilibrium. [See equation (4).]

CHEMISTRY IN MINING

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Chemistry is intimately related to mining. Some of its incidental applications, such as treatment of water and timber, fire-fighting, lighting, etc., are described and the rôle played by chemistry is pointed out.

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We ordinarily think of chemistry in mining as concerned solely with the treatment of the ores. This highly important branch of mining called metallurgy has been discussed and fully treated in many books and articles. However, the incidental applications of chemistry to the winning of ores are scattered throughout the literature. It was thought that a résumé of the latter would perhaps be of interest to students of chemistry and mining.

Deposition of Ores

The majority of ores were originally deposited as sulfides (*e. g.*, FeS_2), arsenides (*e. g.*, $CoAs_2$), or complex sulfarsenides (*e. g.*, $Cu_3AsS_4 = 3Cu_2S \cdot As_2S_5$) and sulfantimonides (*e. g.*, $Cu_8Sb_2S_7 = 4Cu\,S \cdot Sb_2S_3$). These are known as primary ores. If these ores lie between the surface and the ground-water level they are subject to the oxidizing and dissolving effect of rain water and the oxygen and carbon dioxide contained in it. As a result they are taken into solution as sulfates, chlorides, bicarbonates, etc., and deposited in the lower levels as sulfides, oxides, carbonates, etc. Such deposits are known as secondary ores.

Secondary ores of iron, the oxides and carbonates, are much more important than the sulfide. With copper especially, the distinction between the two types of ore is very important. The sulfide at the surface is easily oxidized to the sulfate, which is again reduced by the lower sulfides to form rich ore bodies at the lower water levels. Such secondary enrichment produces the rich deposits of cuprite (Cu_2O) and native copper. Similarly, galena (PbS) and zincblend (ZnS) are the primary ores, while cerussite ($PbCO_3$), anglesite ($PbSO_4$), smithsonite ($ZnCO_3$), and calamine ($2ZnO \cdot H_2O \cdot SiO_2$) are secondary ores.

Action of Air and Water on the Ore Body

As soon as the ore body is opened up by mining and exposed to air and moisture, rapid changes take place. If silicate minerals are present, these reactions often cause a sharp change in volume and resultant swelling of the ground and increased mining difficulties and costs. In mining sulfide ores much heat is generated by oxidation and (especially in abandoned workings) by friction due to caving in of large sulfide bodies. Serious fires are often started in this manner and burn for years. A manager of a large copper company states that ninety per cent of their fires are due to such spontaneous combustion.

If the sulfide ore is exposed too long before treatment it becomes coated with a layer of the oxide. As the flotation process is particularly adapted to sulfides this prevents a high recovery of ore.

Water

Underground waters in contact with air and broken ore become mineralized very rapidly. In copper mines, especially, the water soon attains quantities of copper sulfate and sulfuric acid. The presence of the former is very destructive to iron equipment because of the solution of the iron and precipitation of the copper. Miners' shoe nails, mine rails, pumps and pipe lines are soon destroyed. The acid water (an average of sixteen different mine waters gave four hundred ninety-two parts per million of sulfuric acid) hastens the rusting of all iron objects. Rusting may be considered from the electrochemical point of view as the action of an iron-hydrogen cell, *i. e.*, Fe, Fe^{++}, H^{+}, H_2. The iron passes into solution as the ferrous salt and hydrogen ion is discharged. It is evident that a high concentration of the latter would hasten the action of the cell.

The simplest method to combat acidity is the neutralization of the water with lime. If this is not feasible pumps should be lined with lead, wood, or porcelain, and fitted with bronze plungers. Lead linings are difficult to apply, wear rapidly, and loosen easily. A wood lining, if carefully fitted and swelled with pure water is best, but because of its thickness requires larger and more expensive castings. Cement linings are particularly useful in high concentrations of sulfuric acid (*i. e.*, seventy-five grains per gallon). Column pipes in permanent mine lines should be of a resistant steel alloy or lined with lead or wood. If ores are being leached with acid, all pipes must be lined with lead.

In some cases rusting is reduced by inserting a carbon anode, using the iron as the cathode and connecting a battery. This current tends to plate out iron and reverse the action of the rust cell.

If sulfates and chlorides are absent, the iron is often pickled and rendered passive to oxidation. This process consists in cleaning and polishing the metal, followed by dipping in a solution of an oxidizing agent such as nitric acid, sodium dichromate, etc. This treatment renders the iron resistant to ordinary corroding agents. Often the oxidizing agent is incorporated in a paint which is applied to the iron. However, the passivity is not permanent and if the equipment is used underground the protection is soon removed by scratching and the presence of sulfates or chlorides in the water.

Another method to decrease the action of the rust cell is the casting of zinc on the iron. Zinc, being more reactive than iron, tends to go into solution forcing the iron to plate out. The result is a retardation of the rusting.

In a limestone region there is the usual bother of calcium carbonate deposited in the pipes. The combined action of water and the carbon dioxide dissolved in it take the limestone into solution as soluble calcium bicarbonate. The action is easily reversed and carbon dioxide is given off, precipitating the calcium carbonate. To remove this temporary hardness of water lime may be added to neutralize the bicarbonate, forming the carbonate, or the water may be heated, driving off the carbon dioxide and precipitating the carbonate.

In hot mines, the water upon cooling may deposit iron oxide in the pipes. This heat may result from the depth of the mine (an average of thirty-five mines gave an increase of 1°F. per 64 feet depth), or from the oxidation of the sulfide ores (water at 92°F. flowed from an abandoned stope while water from other parts of the mine was at 60°F.)

Occasionally it is desirable to trace the course of underground water. Fluorescein ($C_{20}H_{12}O_5$), a weak acid, is added and imparts a yellowish brown color which at a concentration of 1 to 40,000,000 can be detected by the eye. It is neither absorbed by clays nor affected by hydrogen sulfide or sulfurous acid. Other coloring materials used are eosine, fuchsine, and methylene blue.

Timber

For support of mines timber is usually the cheapest and most available material. However, as decay soon sets in and greatly shortens the life of the wood, chemical treatment is resorted to. The standard wood preservative is coal-tar creosote—the fraction between the light oils and pitch being used. The treatment often includes heating under pressure to increase the penetration of the creosote. When first treated the lighter oils are a fire hazard but upon standing they soon evaporate and the wood is no more combustible than untreated timber.

Zinc chloride is the standard water-soluble preservative. It is cheap, clean, has no odor, and affords no fire hazard. It is, however, soluble in water and thus easily leached out, besides adding to the weight of the wood. Sodium fluoride and mercuric chloride are used to some extent but are poisonous and more expensive. In some copper mines, the timbers are soaked in the mine water containing copper sulfate. This affords some protection but any iron or steel in contact with it will be attacked.

Gunite, a mixture of portland cement and sand, is often applied under pressure to timbers. It has a high density, is very impervious and is not cracked by hot fires. This treatment, combined with a preservative, is the ideal preparation for lumber to be used in mine work.

Fire-resistant paint containing thirty-three per cent magnesium silicate finds some use. Ordinary whitewash is also fire-resistant.

Lighting

Candles were once widely used in mining. Their light is flickering and easily put out by the exhaust from air drills. Although the initial cost is low, they are more expensive per unit of light than electricity or acetylene. The men tend to waste them by throwing away those half used. Furthermore they consume as much oxygen as a man, besides giving off noxious gases and causing explosions in gassy mines. For these reasons they have been replaced by safety lamps and acetylene lamps.

The Davy safety lamp was put into service in 1816 in England. Its fundamental part is the gauze which dissipates the heat of the flame so that the impinging gases (*e. g.*, methane) are not heated to explosion temperature. It has the advantages that it can be used in a mine atmosphere containing an explosive mixture and, as it will not burn in an atmosphere greatly deficient in oxygen, it warns the men of this danger. Many states require mine bosses to carry one of these lamps.

The acetylene lamp is easily the best as regards economy, ease of handling, and amount of light. The acetylene is generated by the action of water on calcium carbide, $CaC_2 + 2H_2O = C_2H_2 + Ca(OH)_2$. The carbide is manufactured in large electric furnaces by the action of lime on coke, $CaO + 3C = CaC_2 + CO$. A lamp the size of an ordinary fruit jar burns for 8–10 hours, the cap size for 2–3 hours. It consumes only one-fifth the oxygen used by a candle and costs approximately 2 cents per 10-hour shift. Both candle and acetylene lamp have the drawback that they will burn in an atmosphere containing sufficient carbon monoxide to be fatal. If the carbide is not pure small quantities of hydrogen sulfide and phosphine may be generated. The latter is spontaneously inflammable. Most carbide on the market today is manufactured from purified materials, removing this objection. Care must be taken that men do not throw supposedly spent carbide into wet places where any unspent will generate acetylene, forming an explosive mixture with the air.

The relighting of lamps that are filled and sealed before being given to the men is accomplished by built-in igniters. Drops of phosphorus may be placed on a strip coated with paraffin. By drawing this tape over a saw-toothed scratcher the phosphorus is ignited. Drops of fulminate on a strip may be ignited by the blow of a small hammer. The safest and surest consists of a small covered vessel of methyl alcohol placed inside the lamp. A piece of spongy platinum when lowered into the vapor becomes heated by absorption and oxidation of the alcohol until the vapor takes fire. A still simpler method is the insertion of a small flint wheel that can be turned by hand to give sparks.

Of course, electricity is the ideal. It gives a brilliant steady light, is not affected by drafts, consumes no oxygen, and does not pollute the air. Among its drawbacks are—expensive lamp installation, lamps easily

broken, not portable, and short circuits especially in wet places. Most of these objections are overcome in the portable electric light, using a battery of two acid or alkaline cells. In gassy mines, the circuit must be arranged so that it is broken simultaneously with the breaking of the bulbs. Otherwise the glowing filaments would ignite the explosive mixture in the air. Such portable lights have the advantages of being clean, safe around explosives, require no attention, and in the long run are cheaper than acetylene.

Sanitation

The disposal of excreta is an important problem for underground work where a water system is not feasible. The latrines must contain chemicals to disinfect and render the contents liquid. Lime is not a strong disinfectant. Chloride of lime will kill disease germs, but does not affect the hook worm (a common nuisance in mines). Cresol or tricresol in concentrations of 1:19 is efficient. A one per cent solution of caustic soda will kill all disease germs, but a three per cent solution is necessary to destroy the eggs of the hook worm.

Explosives

Explosives are necessary to break rock and ore. Here we have a violent chemical reaction producing a great force in a small volume. It is very costly to break ore without explosives, as in drilling by hand or machine. Such work may cost from ten cents to ninety cents a foot. If a small circular hole is drilled and filled with dynamite, the explosive does the rest. For this reason they are used whenever possible.

Modern straight dynamite is composed of nitroglycerin, sodium nitrate, wood meal, and an anti-acid. Many varieties are produced by adding or substituting ammonium nitrate, nitrocotton, sulfur, nitrostarch, chlorates, etc. The great problem involved in the use of explosives in mining is created by the gases liberated. They all give carbon monoxide. Low-freezing dynamites produce as high as 47% of the gas by volume. Straight nitroglycerin gives 26–34% and gelatin dynamite about 3%. A 30% straight dynamite gives the following gases: carbon monoxide—28.4%, carbon dioxide—20.6%, methane—0.7%, hydrogen sulfide—27.4%.

If the dynamite is burned instead of exploded, nitrogen dioxide, a very poisonous gas, is also produced. In general, if maximum work is performed the fumes are least harmful. Where there are dangerous amounts of inflammable gas or dust a short flame explosive must be used. (This is especially important in coal mines due to the large amounts of coal dust always present in the air.) These contain ammonium nitrate as the chief ingredient and the reduction of temperature is obtained by the water of crystallization of the salts present. The great problem is to invent an explosive that liberates only nitrogen and carbon dioxide, which are harm-

less except insofar they dilute the oxygen of the air, or to invent an explosive that aids mine air.

One step in the latter direction is the introduction of liquid oxygen explosives. Shortly after Linde produced liquid air in 1895 he tried the combination of liquid oxygen and a combustible material. Because of the scarcity of nitrates Germany developed this method during the late war. The liquid oxygen is absorbed in charcoal and crude oil, paraffin or any liquid hydrocarbon is added to aid detonation. The mixture is detonated in the usual way. The advantages claimed for this method are: lower cost, no danger in transportation of high explosives, elimination of misfires (a wait of thirty to forty minutes and all oxygen has evaporated) no danger from storage and no poisonous gases liberated. Among its disadvantages are: must be fired within fifteen minutes because of evaporation of the oxygen, a limited number of simultaneous shots, and the necessity of a liquid air plant. To meet the latter objection a portable apparatus has been developed which has a capacity of three to five liters per hour. A Chile copper mine has been using this type of explosive to blast 20,000 tons of ore a day. However, a recent disastrous premature explosion has caused the government to shut down the liquid oxygen plant. (This is undoubtedly largely due to their wish to aid the use of nitrates.) A new explosive of somewhat the same type is solidified carbon dioxide, which is finding some use in coal mines.

To fire most explosives, detonators are necessary to give the required shock. Practically all have, as the essential ingredient, mercury fulminate. It explodes thus: $Hg_2C_2N_2O_2 = Hg + 2CO + N_2$. Potassium chlorate may be added in concentrations up to 20%. This gives a more efficient mixture due to oxidation of the carbon monoxide to carbon dioxide and the resultant increase in total energy. Also, the chlorate is an endothermic compound and gives up its energy of formation. In general, salts of the oxy-halogen acids give efficient mixtures. Likewise, the oxides and nitrates of the heavy metals are used, provided their decomposition yields the free metal and not a lower oxide.

Fires

Mine fires are especially dangerous to life because of exhaustion of oxygen and generation of carbon monoxide. Many conditions contribute to the fire hazard. Spontaneous combustion occurs (especially in sulfide mines) from oxidation of finely divided ore. Blasting sulfide ores may produce explosive mixtures of dusts which burn to give sulfur dioxide, while waste carbide may generate acetylene, or candles and lamps may be set too close to timber. Probably the chief menace in metal mines today arises from the rapid extension in the use of electricity. Carelessness in installation

or repairing and wires strung on timber cause short circuits, while electric motors placed too close to timber contribute to the danger of fire.

Some type of hand chemical fire extinguisher should be immediately available. The carbon tetrachloride (Pyrene) type is efficient but gives rise to small amounts of phosgene, chlorine, hydrogen chloride, and to a lesser extent, carbon tetrachloride vapor, sulfur dioxide, and carbon monoxide. Its use is not advisable in a confined space with poor ventilation. (The new refrigerant, dichlorodifluoromethane has been found equal to carbon tetrachloride in extinguishing the flames of methane.) The sodium bicarbonate-sulfuric acid type is valuable in hand apparatus as well as mounted on mine trucks which can be rapidly moved to any location.

Water is ordinarily the best, except in zinc mines. Either water or the carbon dioxide spray from the sodium bicarbonate type which carries small amounts of sulfuric acid act on zinc to liberate hydrogen which aggravates the fire. Likewise carbon tetrachloride forms zinc chloride and oxide which are combustible. In such cases foamite is used. This consists of a solution of aluminum sulfate and sodium bicarbonate with licorice extract added to stabilize the foam.

For small fires sawdust can be used. Although it burns it gives no flame and blankets the burning material, excluding the oxygen of the air. Occasionally fires can be extinguished by flooding the region with an inert gas, such as nitrogen, sulfur dioxide, carbon dioxide, or even steam. This is usually expensive because of the large quantities of gas required.

In case of fire it is essential to warn the men immediately. Warning by such means as bells, lights, etc., may fail because of breakdown of circuits. The most efficient warning has proved to be the introduction of stenches into the compressed air streams. Such a chemical must be non-toxic, have a moderate vapor pressure, and an extremely disagreeable odor. Among those that have been used are: butyl and ethyl mercaptan, butyric acid, amyl acetate, amyl thio-ether, phenyl isocyanide, and pyridine. Trinitrotertiarybutylxylene has the most powerful odor (can be detected at 0.000051 part per million). As a nasal and eye irritant, chloracetophenone is superior, being sensitive to 0.021 and 0.0083 part per million, respectively.

(It has been facetiously suggested, by Professor Carpenter, that odor of lilac or roses be sent down regularly to put the men in a happy state of mind. Perhaps an excess of oxygen would obtain more than 100% efficiency. Some rising young mining engineer will undoubtedly develop these newer methods.)

Air

A supply of clean fresh air is a major problem for any mine, especially a deep metal mine. The mine air may contain carbon monoxide, carbon dioxide, sulfur dioxide, hydrogen sulfide, nitrogen dioxide, and dust from

blasting; carbon dioxide from men, animals, lights, and rotting timber; methane, carbon dioxide, and nitrogen as emanations from the strata; carbon monoxide from smoldering fires; and odors from excretions of men and animals. It may also be saturated with water vapor if it has passed through wet workings.

Methane—CH_4—Firedamp.—Methane is especially encountered in coal mining, where it enters from the coal seams. In times of low barometric pressure the amounts may increase greatly. It has no effect on the human system and no appreciable odor, but harms by displacing oxygen. Because of its combustibility it forms dangerous mixtures with air or dust. The original test for methane was by means of the safety lamp. To any experienced man, the transparent blue flame over and surrounding the brighter part of the flame produced by methane will indicate its presence at a minimum concentration of 1%. The safety lamp has the further advantage that a deficiency of oxygen is indicated, as the light is extinguished in 17% oxygen, although the percentage may fall to 10% without injury to man. This is especially important in old mine workings. The most accurate test for methane is the determination in a standard gas-analysis apparatus. Here the gas is oxidized, $CH_4 + 2O_2 = CO_2 + 2H_2O$ (liquid), over a glowing platinum wire and the diminution of volume is calibrated in per cent methane.

Carbon Dioxide—CO_2—Choke Damp or Mixed with Nitrogen—Black Damp.—Carbon dioxide is rarely found in concentrations to exceed 4–5%. Such amounts are not injurious for periods of thirty minutes although more than 2% seriously reduces efficiency and 3.5% causes deep breathing. The ordinary breathing of a man uses in one hour all the oxygen in 2.6 cubic feet of air. This amount is doubled for a man at work while a candle or lamp uses about the same, and a horse or mule three to five times this amount. Thus, for the sake of efficiency the carbon dioxide concentration should be kept low by good ventilation. When entering a region that may contain high amounts of this gas besides a deficiency of oxygen, a breathing apparatus must be used. This should include a supply of compressed oxygen and a soda-lime canister to absorb carbon dioxide.

Nitrogen Dioxide.—This compound is produced by burning dynamite. Fortunately it is seldom formed in quantities large enough to be dangerous. Its presence may be detected qualitatively or quantitatively by the color reaction with phenol-disulfonic acid.

Sulfur Dioxide—SO_2 and Hydrogen Sulfide—H_2S—Stone Damp.—These gases are produced in the blasting of heavy sulfides. Hydrogen sulfide particularly is a very toxic and insidious gas. Alarming symptoms are produced within a few minutes in an atmosphere containing 0.05%. Death is caused in two to fifteen minutes by 0.06%. It is even more acutely

poisonous than carbon monoxide. Fortunately, it is rarely produced. To test for these gases, they are collected in absorption tubes containing an ammoniacal solution of cadmium chloride. The sulfur dioxide dissolves as the sulfite and the hydrogen sulfide is precipitated as cadmium sulfide. The sample of air should be taken as soon as possible after formation because of their interaction to form sulfur, $2H_2S + SO_2 = 3S + H_2O$.

Soot, smoke vapors, etc., may be removed in a breathing apparatus by cotton pads and activated charcoal.

Dust.—Dust of all kinds, especially silica dust, is harmful to the lungs and nasal passages. Where water is plentiful the ground should be sprinkled regularly. If water is scarce calcium chloride may be distributed throughout the mine. Because of its hygroscopic nature it retains the moisture for a greater length of time and aids in decreasing dust.

Carbon Monoxide.—This substance, because of its ease of formation, is the most dangerous of the poisonous gases. It is formed by all explosives and wherever combustion takes place in a limited supply of oxygen. Man shows distress at a concentration of 0.1%, while death is likely when 0.2% is breathed for four or five hours or 0.4% for one hour. Because of its importance various methods have been devised to detect the gas.

Animal Behavior.—The oldest test and one still widely used is the effect produced on mice or canaries. The rate of chemical change in the metabolism of such animals is much more rapid than for man. It is stated (Haldane) that a mouse weighing one-half ounce consumes more than fifteen times the oxygen that a like amount of human flesh consumes. Until recently canaries have been the official test. They have the advantage over white mice in that distress is more clearly shown and collapse is indicated by fall from perch. Both, however, quickly recover when placed in fresh air and can be used many times. Recent work has shown that Japanese waltzing mice are even more sensitive than canaries. In a concentration of approximately 0.1% carbon monoxide the former give a positive reaction after 5 to 10 minutes while the latter are not affected after 75–131 minutes. Even though such animals are able to warn man in time to prevent death, yet the margin of time in 0.25% carbon monoxide between serious response of man and animal is too narrow to be of practical use for avoiding harmful exposure.

Chemical Tests.—Iodine pentoxide (Hoolamite), $I_2O_5 + 5CO = 5CO_2 + I_2$. The iodine liberated can be dissolved in chloroform or carbon disulfide and the color compared with standards, or the carbon dioxide may be caught in barium hydroxide and the excess base titrated with oxalic acid. In the newer types a bulbful of the air to be tested is forced over pumice containing the pentoxide and fuming sulfuric acid. The color produced is compared with standards calibrated in terms of 0.2, 0.3, 0.5, and 1.0% carbon monoxide. The color fades and the same chemicals may be used seven or

eight times. Hydrogen sulfide, hydrogen chloride, ethane, and gasoline vapor must be removed with activated charcoal.

Palladium Chloride.—$PdCl_2 + CO + H_2O = 2HCl + CO_2 + Pd$. This is the newest and perhaps the best of the chemical tests. Palladium chloride in a water-acetone solution is contained in a hermetically sealed, thin-walled, cotton-covered glass tube. When a test is to be made the glass is crushed and the cotton wet with the solution is exposed to the air. The free palladium colors it a light brown to black according to the amount of carbon monoxide in the air. Comparison color charts are calibrated from 1 to 10 parts of carbon monoxide per 10,000 of air. Tests have shown that this method will give semi-quantitative results in the range 2–10 parts per 10,000 of air. Unfortunately, other reducing agents as ethane, hydrogen sulfide, or gasoline vapor give similar results. But as none of them are desirable in the air, the test is very valuable.

Hopcalite.—When carbon monoxide mixed with oxygen of the air is passed over this catalyst the former is oxidized to carbon dioxide, liberating energy. If the catalyst surrounds the hot junctions of a thermocouple the resultant electric current may be employed to give a warning. Usually a bell is rung by a relay when the concentration reaches 4 parts per 10,000 of air.

If time and skill are available, by far the best test for any of these gases is a quantitative determination in a standard gas analysis apparatus. Portable outfits, such as the Orsat, which analyze for carbon monoxide and dioxide, oxygen and methane, can be obtained. In many mines a regular schedule of such determinations is carried out.

In studies of mine and tunnel ventilation sulfur trioxide—SO_3—is used to determine the flow of air, direction of currents, and rate of mixing. An apparatus containing fuming sulfuric acid ($H_2SO_4 + SO_3$) on pumice stone is attached to a rubber syringe bulb. A squeeze liberates sulfur trioxide which combines with droplets of moisture to form a white cloud of sulfuric acid.

Acknowledgment

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No man ever arrived at the top without a climb.—J. G. JONES

THE HISTORY OF CHEMISTRY TEACHING IN AMERICAN HIGH SCHOOLS

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Among the factors which led to the inclusion of chemistry in school curricula the utilitarian spirit of the American people was possibly most significant. Its popularity rapidly increased—more rapidly in the academies than in the colleges. Its position in the curricula of the high schools was firmly established shortly after the middle of the nineteenth century.

During the first three-quarters of the nineteenth century chemistry teaching was superficial, but rather practical. This period was followed by one in which the laboratory tended to dominate; mental discipline became the commonly accepted aim of the course. Since about 1910 there have been evident trends toward the development of social objectives, toward greater emphasis on the practical applications of the science, and toward a better adaptation to the needs and interests of the pupils.

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I

At the beginning of the nineteenth century there were in the United States several factors which fostered a popular and an educational interest in the natural sciences in general and in chemistry in particular. The secondary education of the time was largely classical in character, but the popular temper was dominantly rationalistic and utilitarian. The demand for democratic education, the necessity for exploiting the natural resources, the practical outlook of the pioneers—these and other factors were conducive to utilitarian interests and to utilitarian education. Economic, social, and intellectual forces had created a world far different from that of two centuries before; the schools still adhered to an outmoded and formalized humanism.

Science had powerful friends among some of the leading statesmen of the new country. The names of Franklin and Jefferson were eminent in the movement to disseminate science as well as in the realm of political activity. Both proposed plans of popular education that were essentially utilitarian. At the early age of twenty-one Benjamin Franklin had organized a Junto, the members of which discussed morals, politics, and natural philosophy. Chemical questions frequently claimed their attention (*1*). In 1743 Franklin advocated the organization of an American Philosophical Society. The members were to correspond with each other in an effort to promote the diffusion of science. The subjects of their correspondence included, among other things, "new discoveries in chemistry, such as improvements in distillation, brewing, and assaying of ores" (*2*).

Thomas Jefferson prepared a *Bill to Establish a System of Public Education* for submission to the general assembly of Virginia. Besides elementary and secondary schools it provided for a state university (*3*). To the technical school of the proposed university, Jefferson (*4*) prophesied,

. . . will come the mariner, carpenter, shipwright, pump-maker, clock-maker, machinist, optician, metallurgist, founder, cutler, druggist, brewer, vintner, distiller, dyer, painter, salt-maker, glass-maker, to learn, as much as shall be necessary to pursue their arts understandingly, of the science of geometry, mechanics, statics, hydrostatics, hydraulics, hydrodynamics, navigation, astronomy, geography, optics, pneumatics, acoustics, physics, chemistry, natural history, botany, mineralogy, and pharmacy.

A large proportion of the plans of education submitted by other public-spirited thinkers were utilitarian in nature, although scientific studies were not included in all of them (*5*). A particularly interesting scheme was the one composed at the request of Jefferson by du Pont de Nemours. The author included chemistry among the studies of the proposed secondary school (*6*).

The scientific interests of the American people were attested and at the same time were fostered by the organization of numerous scientific societies and research institutions. From the establishment of the American Philosophical Society in 1743 until the recognition of science by the federal government in the incorporation of the National Academy of Sciences (1863) there was an almost constant increase in the number and importance of these associations. The first association devoted exclusively to chemistry seems to have been the Chemical Society of Philadelphia; it was founded by James Woodhouse in 1792. The acquisition of information relative to the minerals of the United States was one of its principal purposes (*7*). The prevailing emphasis on the utilitarian values of chemistry was vividly revealed in an oration delivered before the society in 1798 by Thomas P. Smith (*8*). The Chemical Society of Philadelphia was dissolved in 1809, but it was succeeded two years later by the Columbian Chemical Society of Philadelphia (*9*).

The most influential of all American scientific societies was organized in 1840 as the Association of American Geologists. Seven years later the name was changed to the American Association for the Advancement of Science. With the increasing specialization of the sciences the association split into various sections. The organization of the American Chemical Society in 1876 was further evidence of the specializing trend (*10*).

Another significant stimulus to serious scientific research and to the diffusion of scientific knowledge resulted from the organization in 1846 of the Smithsonian Institution (*11*).

More effective as agents of popular diffusion were the scientific periodicals, technical and popular. A large number of such journals appeared during the first half of the nineteenth century. Although most of them had comparatively brief careers, a few exercised considerable influence; and even those that plunged speedily into journalistic graves testified to a widespread interest in science. The number of scientific periodicals beginning publication in each decade from 1790 to 1869 (*12*) is shown in Table I.

TABLE I

Number of Scientific Journals in the United States Beginning Publication during Each Decade from 1790 to 1869

Decade	*Number*	*Decade*	*Number*	*Decade*	*Number*
1790–99	4	1820–29	17	1850–59	14
1800–09	3	1830–39	19	1860–69	21
1810–19	14	1840–49	14		

The earliest journal devoted to science in general was the *Medical Repository;* it was published from 1797 to 1826. The most important of the early periodicals was the *American Journal of Science and Arts.* It was founded in 1818 by Benjamin Silliman and has continued an uninterrupted existence until the present time (*13*).

The first periodical devoted to chemistry seems to have been the *Boston Journal of Chemistry;* it began publication in 1866. The *Journal of Applied Chemistry* (New York) was established the same year. The *Chemical News* (New York) was begun in 1867 and the *American Chemist* (New York) in 1870 (*14*).

The people themselves during the thirties and forties demanded information on scientific subjects. The insistence of this demand was discovered in the prominent place given to science in the courses and programs of the ubiquitous lyceums and mechanics' institutes. It was discovered in the eager hearing given to such popular science lecturers as Griscom (*15*) and Youmans (*16*). And it was discovered in the favoritism shown to science lecturers in the Lowell Institute of Boston. Out of the six hundred fifty-eight lectures delivered during the first eight years of the Institute's history four hundred seventy-five were on science. Benjamin Silliman delivered seventy-two on chemistry (*17*). It is significant that every one of the scientific series was repeated, while of the lectures on non-scientific subjects only two series were repeated in their entirety. Having in these various ways demanded for themselves a knowledge of science, it was natural that the American people should demand it for their children.

II

Chemistry appeared among the offerings of several American colleges during the eighteenth century. As a separate subject it was first taught in the medical schools. With the opening in 1767 of the medical school of King's (Columbia) College there was established what seems to have been the first professorship of chemistry in America. In that year James Smith, M.D., entered upon his duties as professor of chemistry and materia medica (*18*). In 1792 Samuel L. Mitchill, M.D., was appointed professor of "Natural History, Chemistry, Agriculture and Other Arts Depending Thereon" (*19*). Mitchill claimed that he adopted the "anti-phlogistic system" and that he taught the "reformed chemistry of the French and

unfurled the banner of Lavoisier sooner . . . than any other professor in the United States" (*20*). Yet his own chemical contributions were all practical in their nature (*21*).

To the medical school of the College of Philadelphia (University of Pennsylvania) goes the honor of having the first chair in chemistry apart from other sciences; Benjamin Rush was appointed professor of chemistry in 1769 (*22*). Rush ranked with Franklin and Jefferson as an eminent exponent of scientific and broadly utilitarian tendencies in early American education (*23*). His teaching inspired his students with an interest in chemistry, many of them abandoning medicine for it. From his classroom went out such leaders of early chemistry as James Woodhouse and Adam Seybert.

Other American colleges establishing chairs of chemistry during the eighteenth century were William and Mary (1774) (*24*), Washington College (1782) (*25*), Harvard (1783) (*26*), Princeton (1795) (*27*), and the University of Georgia (1800) (*28*).

A significant step in the history of chemistry teaching was taken with the appointment in 1802 of Benjamin Silliman as professor of chemistry and natural history at Yale. Silliman gave his first lecture on chemistry to the senior class in April, 1804; his subject was the history, progress, nature, and objects of chemistry (*29*). In October of the same year he began to teach chemistry to the seniors who were to graduate in 1805. His course consisted of four lectures weekly, sixty or more in all, with notices of mineralogy (*30*). The laboratory for his use was constructed partly below ground, the architect evidently considering chemistry a dangerous and mysterious science.*

The most significant contributions of Silliman to science were perhaps not made in college halls. He was especially gifted as a journalist and as a popular lecturer. In 1831 he began giving popular lectures to mechanics' institutes. From that time on his services as a speaker were in frequent demand. In addition to his many lecture engagements Silliman constantly corresponded with leading scientists in all fields (*31*).

Although in the medical schools the medical implications of chemistry were stressed, as a collegiate study it was considered valuable largely for its contributions to mineralogy, agriculture, and manufacturing. Scientific agriculture was still in its infancy, and manufacturing did not gain a significant foothold for several decades after the Revolution; serious attempts were made, however, to exploit the mines of the virgin country. To this task chemistry lent ready assistance. The titles of papers published by

* The prevailing ignorance of chemistry was further evidenced by Silliman's efforts to have retorts made. He sent a retort, broken at the neck, to an East Hartford glass blower, ordering a dozen like it. The dozen were furnished, all like the sample—broken at the neck!

the early American chemists reveal the strong interest felt by them in mineralogy (*32*). In the titles of college chairs chemistry was frequently combined with mineralogy.*

Among the factors operating against the extension of chemistry in the colleges were the established classical tradition and the lack of financial support. The lack of funds was an especially serious deterrent both to the endeavors to establish chemistry chairs (*38*) and to the efforts to build up collections of experimental apparatus. Even when sufficient money was available, apparatus could not always be obtained in America. As a result comparatively few demonstrations accompanied the chemistry lectures in most colleges (*39*).

In some of the colleges the utilitarian spirit of the chemistry instruction approached that exhibited by such leaders as Franklin and Jefferson. Geneva (Hobart) College in 1824 made a significant departure with the establishment of an English course in which the sciences played a prominent part. Chemistry was particularly susceptible to practical applications. Under the professor of chemistry were to be studied "*Chemistry;* the *Principles of Dyeing, Bleaching,* etc.; the nature and use of different *Earths* and *Soils;* the fertilizing qualities and effects of different *Substances; Mineralogy* and *Botany*" (*40*).

Popularity of the chemistry courses in the colleges was effectively promoted by a number of outstanding college professors. Through stimulating college lectures, through numerous college and secondary school textbooks, and through repeated appearances before lyceums and mechanics' institutes, these men exerted a remarkable influence on the dissemination of scientific knowledge. Chemistry presented a brilliant array with such men as Silliman, Rush, Hare, and Cooper. Robert Hare enjoyed a brilliant career from 1818 to 1847 as professor of chemistry in the medical school of the University of Pennsylvania (*41*). Probably the most versatile of the four was Thomas Cooper, the son-in-law of Joseph Priestley. In 1811 he was appointed professor of chemistry, mineralogy, and geology at Dickinson College (*42*), and in 1816 professor of chemistry and mineralogy at the University of Pennsylvania. Three years later through the influence of his friend, Jefferson, Cooper secured an appointment as professor of chemistry, mineralogy, natural philosophy, and law at the University of Virginia; but the rabid attacks of the theologians forced him to resign before he had given a lecture (*43*). Instead he accepted the chair of chemistry at South Carolina College. In 1821 Cooper became president of that institution (*44*).

By the middle of the nineteenth century chemistry was fairly well estab-

* Some of the early professorships including both sciences were those at Bowdoin (1805) (*33*), Dickinson (1811) (*34*), Hamilton (1812) (*35*), Dartmouth (1820) (*36*), and St. John's College (1813) (*37*).

lished in college curricula, but considerable improvement in its status was needed. The amount offered was usually meager and it suffered in comparison with the well-established classics. These conditions were rapidly improved during the second half of the century. The founding of several engineering schools and of The Johns Hopkins University and the enactment of the Morrill Act exerted considerable influence toward their amelioration (*45*).

III

Utilitarian aims dominated the early academies more than they did the colleges. Consequently, the sciences found a greater welcome in their curricula. Natural philosophy and astronomy were the earliest academy sciences, but chemistry closely approached them in popularity.

During the third decade of the nineteenth century impetus was given to the dissemination of scientific knowledge by the establishment of a number of schools devoted primarily to the training of boys in the sciences applied to agriculture and the industrial arts. One of the earliest of these institutions was the American Literary, Scientific, and Military Academy founded at Norwich, Vermont, in 1820. James F. Dana was professor of chemistry and mineralogy from 1820 to 1825 and Joseph Barratt was professor of chemistry, botany, and mineralogy from 1824 to 1829 (*46*).

A more purely scientific school was the Gardiner Lyceum at Gardiner, Maine, which opened on January 1, 1823. Principal Benjamin Hale gave lectures on chemistry and agricultural chemistry (*47*).

The most successful scientific school founded during this period was Rensselaer School; it opened in 1824. The purpose of the school as expressed in a letter by the founder (*48*) was—

> To qualify teachers for instructing the sons and daughters of farmers and mechanics, by lectures and otherwise, in the application of experimental chemistry, philosophy, and natural history, to agriculture, domestic economy, the arts, and manufactures.

A significant feature of the school was the emphasis placed upon the experimental method of teaching. As applied to chemistry the method used is indicated in the following order (*49*):

> In giving the course in chemistry, the students are to be divided into sections, not exceeding five in each section. These are not to be taught by seeing experiments and hearing lectures according to the usual method. But they are to lecture and experiment by turns, under the immediate direction of a professor or a competent assistant. Thus by a term of labor, like apprentices to a trade, they are to become operative chemists.

An agricultural seminary was established at Derby, Connecticut, in 1824 by Josiah Holbrook. Considerable attention was given to the practical applications of chemistry in this school (*50*). In the following year the

Massachusetts legislature appointed a commission to draw up plans for an institution similar to that at Derby (*51*). The commissioners submitted a report, but the legislature neglected to adopt it.

A factor limiting the number of academies offering chemistry was the lack of scientific training on the part of many academy teachers. But, owing to the informational character of the science, this was not an insuperable handicap. Many teachers were able to acquaint themselves sufficiently with the facts of chemistry to give their pupils in turn some smattering of chemical knowledge. Griscom (*52*) taught himself the science; Silliman (*53*) did to a certain extent. Such a procedure, of course, fostered superficiality.

Very little evidence is available regarding the curricula of the early academies in most states. The existing records are most complete for the academies of New York (*54*) and North Carolina (*55*). In Table II are listed the number and percentage of academies offering chemistry from 1810

TABLE II

Number and Percentage of Academies in New York and North Carolina Offering Chemistry from 1810 to 1850

	1810–19			*1820–29*			*1830–39*			*1840–49*
	North Carolina		*New York*	*North Carolina*		*New York*	*North Carolina*		*New York*	*New York*
	Boys	*Girls*		*Boys*	*Girls*		*Boys*	*Girls*		
No. academies studied	11	11	21	22	19	33	18	15	66	153
No. offering chemistry	2	1	0	3	12	8	7	10	63	138
Percentage offering chemistry	18	09	0	14	63	24	39	67	95	90

to 1850. The academies studied do not include all those existing in the two states, but there is no reason to believe that they are not a fair sampling. It is evident from the table that the increase in proportion of boys' academies in North Carolina offering chemistry during three decades was very slight. The girls' schools show a much greater increase, while the New York academies reveal an even more impressive increase. Other evidence also indicates that chemistry was more popular in girls' than in boys' academies.

Very little is known of the curricula in the trans-Appalachian academies, but there is considerable fragmentary evidence that chemistry was a popular subject. It was being offered at the Cincinnati Female Institution in 1837 (*56*) at the Lancaster (Ohio) Institution for the Instruction of Young Ladies in 1838 (*57*), at Owen's School, New Harmony, Indiana, in 1826 (*58*), and at the Hillsborough (Illinois) Academy in 1837 (*59*).

Examination of the number of editions of chemistry textbooks mentioned in Barnard's list of American textbooks corroborates the conclusions reached from a study of the academy courses of study. Both sources of evidence indicate a steady acceleration from decade to decade in the fre-

quency of chemistry instruction. In Table III are listed the number of

TABLE III

Number of Different Chemistry Textbooks Published between 1790 and 1859 (Barnard's List)

Publication Dates	*1790–99*	*1800–09*	*1810–19*	*1820–29*	*1830–39*	*1840–49*	*1850–59*	*No date*
First editions	2	4	12	19	16	37	44	
Other editions		1	4	5	4	5	15	
Total	2	5	16	24	20	42	59	45

different chemistry textbooks published between 1790 and 1859 that were mentioned by Barnard (*60*). Only books of American publication are included in the table. Since college textbooks were frequently used in academies, no attempt was made to distinguish between textbooks intended for college and for secondary school use; all were listed. All the textbooks mentioned by Barnard were listed in the table in the row, "First editions." In many cases he included several subsequent dates of publication; these were listed in the row, "Other editions."

IV

The early New England high schools had apparently less diversified curricula than the academies. In the second high school to be established in Massachusetts, the Worcester Female High School, chemistry was taught the first year (1824) (*61*). In the following year chemistry was required in the Girls' High School at Boston (*62*).

In the Middle Atlantic States, although the high-school movement was more tardy in getting under way, chemistry found a ready welcome. The Central High School of Philadelphia introduced the science into its curriculum in 1842 (*63*), the Lockport (New York) Union School in 1848, and the New York Free Academy in 1850 (*64*). The progress of chemistry in the high schools of New York (*65*) and New England (*66*) during the middle decades of the century is indicated in Table IV. The data for the

TABLE IV

Number and Percentage of High Schools in New York and New England Offering Chemistry from 1830 to 1889

	1830–39	*1840–49*	*1850–59*		*1860–69*		*1870–79*	*1880–89*
	New Eng.	*New Eng.*	*New York*	*New Eng.*	*New York*	*New Eng.*	*New York*	*New York*
No. high schools studied	3	5	164	5	202	6	216	261
No. offering chemistry	1	4	130	3	142	5	141	156
Percentage offering chemistry	33	80	79	60	70	83	65	60

New England schools include the representative high schools studied by Grizzell. The data for New York include all schools, both high schools and academies, reporting to the regents. A slight decline is discernible in the proportion of New York schools offering chemistry.

Chemistry was required by law in Massachusetts towns containing 500 families from 1857 until the repeal of the statute in 1898 (*67*). It would be a mistake, of course, to conclude that the subjects prescribed by this law were always "taken"; often there may not have been "sufficient demand."

Early high-school curricula west of the Appalachians were particularly realistic and utilitarian. A large number of short science courses was the rule. In some schools as many as eight or ten sciences were offered (*68*). Chemistry was less popular than natural philosophy and, during the last decades of the century, it was less popular than physical geography and botany. The rather consistent position chemistry retained during the last half of the nineteenth century is revealed in Table V. This table gives

TABLE V

Number and Percentage of Pupils Studying Chemistry in Ohio High Schools from 1860 to 1900

	1860	*1870*	*1880*	*1890*	*1900*
No. pupils reported	13,182	18,828	30,111	36,492	56,952
No. studying chemistry	1,141	664	1,737	2,140	3,053
Percentage studying chemistry	09	04	06	06	05

at intervals of ten years the number of pupils enrolled in high schools in Ohio (*69*) and the number and percentage of high-school pupils studying chemistry.

The status of high-school chemistry in the other states was similar to that reported for Ohio. In 1867 Henry Barnard made a study of the public schools in thirty of the larger cities of the United States. He found that chemistry was taught in twenty-six of them. Only natural philosophy and physiology exceeded it in popularity (*70*). Eleven years later the United States Commissioner of Education sent a questionnaire on the teaching of chemistry and physics to a large number of high schools. Replies were received from 176 public high schools in cities of 7500 or over. Only twenty-two of the total number reported that no course in chemistry was being offered (*71*).

Further light is thrown on the trends in chemistry teaching by Stout's study of selected school curricula in the North Central States. Table VI

TABLE VI

Number and Percentage of High Schools in North Central States Offering Chemistry from 1860 to 1900

	1860–65	*1866–70*	*1871–75*	*1876–80*	*1881–85*	*1886–90*	*1891–95*	*1896–1900*
No. curricula examined	20	20	20	20	25	30	40	40
No. offering chemistry	17	16	18	13	20	18	28	26
Percentage offering chemistry	85	80	90	65	80	60	70	65

lists the number and percentage of schools among those Stout (*72*) studied, which offered chemistry during each five-year period from 1860 to 1900. The data reveal a slight decline in the later years similar to that shown in New York.

Chemistry and physics led the other sciences in the amount of time devoted to their study. At the middle of the century the average length of the term for chemistry was 0.69 year. In 1891–95 the average was 0.83 year and the mode was one year. The mode for the other sciences with the exception of physics was one-half year in 1895 (*73*). It is significant that, although in the later years there was a decrease in the number of sciences taught, the total amount of science remained constant. Chemistry was, as a rule, an elective subject (*74*).

A significant trend that is having serious consequences is the marked decline since 1900 in the proportion of high-school pupils studying science. The phenomenal rise in the two new sciences, biology and general science, has not offset the losses for the older sciences. Chemistry alone among the older sciences seems to have retained the position it held at the beginning of the century. In New York State there has actually been an increase within recent years. Evidence of the trends in New York (*75*) and in the nation (*76*) as a whole is given in Table VII. In 1927 Petrich found that

TABLE VII

Number and Percentage of High-School Pupils Studying Chemistry in New York and in the United States from 1900 to 1928

	No Pupils Reported		*No. Studying Chemistry*		*Percentage Studying Chemistry*	
	N. Y.	*U. S.*	*N. Y.*	*U. S.*	*N. Y.*	*U. S.*
1900	66,929	519,251	2,109	40,084	03	07.72
1905	86,736	679,702	2,253	45,980	03	06.76
1910	122,208	739,143	4,215	50,923	03	06.89
1915	160,638	1,165,495	10,947	86,031	07	07.38
1920	188,457		12,570		07	
1922		2,155,460		159,413		07.40
1925	282,604		22,622		08	
1928		2,896,630		204,694		07.04

64.1% of the 385 high schools he investigated offered chemistry. Only physics (75.3%) and general science (68.6%) were taught in a larger number of schools. The number of pupils studying chemistry was 10.3% of the total enrolment (*77*).

In addition to the regular course in chemistry a number of high schools within the past decade have offered courses in applied chemistry. In 1920 there were 1097 pupils of New York high schools enrolled in applied chemistry courses; five years later there were 3590 (*78*). Hunter found a similar trend in his nation-wide questionnaire studies of 1908 and 1923. Out of

276 high schools answering his questionnaire in 1908, 248 offered chemistry. In 1923, 398 courses of chemistry were given in 357 high schools; the introduction of courses in applied chemistry accounted for much of the increase (*79*).

Another trend in science teaching revealed during the past two decades has been that toward some definite sequence in the sciences. During the nineteenth century apparently no definite sequence existed: any science might be taught during any year of the high school. Hunter's study showed that by 1923 chemistry and physics had become almost equally interchangeably eleventh- and twelfth-year subjects (*80*).

One factor outside of the high schools that has somewhat influenced the high-school offerings has been college entrance requirements. Kilander in 1928 studied the entrance requirements in 290 of the 552 liberal arts colleges in the United States. All of them accepted entrance units in chemistry. No other science was accepted by all colleges; 99% accepted physics and 87% botany (*81*). Twenty-eight of the colleges limited the choice of the required science subject, permitting the other sciences among the electives. Chemistry again took precedence over the other sciences: 100% of the 28 colleges specified chemistry, while 93% specified physics and only 57% botany (*82*).

V

The history of the aims, methods of teaching, and content of high-school chemistry divides roughly into three periods. Since the various periods blended into each other, and since outside of New York comparatively little state control of the high schools has been exercised, no exact boundaries can be set to the periods. In general, however, the first period included the first eight or nine decades of the nineteenth century; the second period included the last decade or two of the nineteenth and the first decade or first decade and a half of the twentieth century; and the last period included the years since about 1910 or 1915. With changes in the aims of chemistry teaching there were corresponding changes in the methods of teaching and in the content, organization, and presentation of the courses. The changes in aims, in methods, and in content were not always simultaneous, but they synchronized somewhat roughly.

The most obvious features of high-school chemistry during the first period were its informational character, its utilitarian nature, its superficiality, and the memoriter character of the teaching methods.

The type of chemistry offered in the early secondary schools was to a greater extent than in the case of physics conditioned by the status of the science itself. Prior to 1800 chemistry had been largely a handmaiden of medicine, mineralogy, and a few of the other practical arts; even after the turn of the century the odor of the apothecary shop clung to it. In the

following decades rapid progress was made in the development of the science (*83*).

That a large proportion of the progress was practical rather than theoretical was to be expected. The popular concept of the duties of chemists is exemplified in a letter written by President John Adams (*84*) in 1817 to Professor John Gorham. The president said:

> Chymists! Pursue your experiments with indefatigable ardor and perserverance. Give us the best possible Bread, Butter and Cheese, Wine, Beer and Cider, Houses, Ships and Steamboats, Gardens, Orchards, Fields, not to mention Clothiers or Cooks. If your investigations lead accidentally to any deep discovery, rejoice and cry "Eureka!" But never institute any experiment with a view or a hope of discovering the first and smallest particles of matter.

An examination of the early textbooks reveals a practical as well as an informational aim on the part of the writers. John Pennington (*85*) on the title page of his "Chemical and Economical Essays" (1790) stated that the book was "designed to illustrate the connection between the theory and practice of chemistry, and the application of that science to some of the arts and manufactures." A similar aim was expressed by Thomas Ewell, M.D., (*86*) on the title page of his "Plain Discourses on the Laws or Properties of Matter" (1806). Still more utilitarian in character was John R. Coxe's (*87*) translation of Orfila's "Practical Chemistry" (1818). This textbook consisted of a "description of the processes by which the various articles of chemical research, in the animal, vegetable, and mineral kingdoms [were] procured, . . . to which [was] added a variety of subjects of practical utility." No theories or laws were treated in this work, except incidentally in connection with the description of the preparation of various elements and compounds.

The difficulties in the way of a logical presentation of chemistry were enhanced by the disorganized state of the science. John Vaughan (*88*) in the preface to his "Chemical Syllabus" (1799) wrote as follows:

> In reflecting on the important and difficult task . . . of exhibiting to the public a course of experiments on Chemical Philosophy, . . . one of the greatest obstacles that presents itself is the diffused state of chemical phraseology.

One of the most widely used college textbooks in chemistry during the first few decades was William Henry's "Elements of Experimental Chemistry." An examination of the 1822 edition of this work will illustrate the status and organization of the science at the time. In the first volume the author described the laboratory furnishings necessary for those intending to be practicing chemists. He then discussed, respectively, affinity, caloric, light, gases, water, electricity, alkalies, earths, and acids and their compounds (*89*).

In the second volume Henry discussed phosphorus, boracic acid, fluoric acid, iodine, metals, and vegetable and animal substances (*90*). The met-

als were classified into four groups: (*a*) malleable metals; (*b*) brittle and easily fused metals; (*c*) brittle metals that are fused with difficulty; (*d*) refractory metals (*91*). It is rather significant that this is a practical rather than a theoretical classification. The descriptive part of the text was followed by twenty-five pages devoted to the analysis of mineral waters, twenty-seven pages devoted to the examination and analysis of minerals (*92*), and thirty-two pages devoted to the "application of chemical tests and reagents to useful purposes" (*93*).

Henry's preface corroborates the conclusion reached concerning the practical aim of chemistry. After a lengthy exposition of the relation of chemistry to the practical arts, he concluded (*94*) as follows:

> The general uses of chemistry have been thus fully enlarged upon, because it is a conviction of the utility of the science, that can alone recommend it to attentive and persevering study.

Among the most popular chemical textbooks written specifically for secondary schools was Comstock's "Elements of Chemistry." First published in 1831, it had run through forty-nine editions by 1837 (*95*). In 1823 Comstock had published a still more elementary textbook, the "Grammar of Chemistry" (*96*). The whole text of the "Elements" was popularly written, entirely descriptive, and very thin from the standpoint of chemical knowledge. Very little theory was included, although the law of definite proportions was stressed. The experiments listed were usually of a fantastic type.

The practical and informational aim continued to dominate high-school chemistry for some years past the middle of the century. As late as in 1867 Steel (*97*) stated in the preface of his "Fourteen Weeks in Chemistry" that

> Unusual importance was given to that practical part of chemical knowledge which concerns our everyday life in the hope of bringing the schoolroom, the kitchen, the farm, and the shop in closer relationship.

And in 1880, as shown in Table VIII, this textbook was the one most widely used in large city high schools (*98*).

TABLE VIII

Chemistry Textbooks Most Widely Used in 1880 in Public High Schools in Cities of 7500 Population or Over

Author	*Name of Textbook*	*Number of Schools Reporting Its Use*
J. Dorman Steele	Fourteen Weeks in Chemistry	60
C. W. Eliot and F. H. Storer	Manual of Inorganic Chemistry	32
E. L. Youmans	Classbook of Chemistry	20
Le Roy C. Cooley	Elements of Chemistry	10

Four years before the publication of Steele's work, a similarly practical aim had been expressed in the preface of Worthington Hooker's "Chem-

istry" (*99*). The title page of John A. Porter's "Principles of Chemistry" (1874) stated that the text embraced "the most recent discoveries in the science and the outlines of its application to agriculture and the arts" (*100*).

Most of the early textbooks in chemistry designed for secondary schools were decidedly superficial. The majority of the authors wrote in several fields; naturally, their knowledge in any one field could scarcely be very profound. Considering the poor training of the average teacher and the general low opinion of the non-classical subjects, the treatment of chemistry in the classroom was probably not superior to that given in the textbooks. J. L. Comstock, for example, contributed popular textbooks on geology, mineralogy, chemistry, natural philosophy, physiology, and botany. Barnard included in his list of textbooks twenty-four different books by Comstock (*101*). He listed thirteen different titles by Amos Eaton, including works on botany, chemistry, geology, zoölogy, natural philosophy, and surveying (*102*).

The titles of the early textbooks somewhat reveal the superficial character of their contents. Typical titles were "Chymical Catechism" (*103*), "Grammar of Chemistry" (*104*), "Conversations on Chemistry" (*105*), "The Juvenile Philosopher: Chemistry" (*106*), and "Chemical Atlas" (*107*).

Comparatively little originality was exercised by most of the early textbook writers in compiling their works. The absence of copyright laws permitted wholesale pirating of textbooks. Dr. Elijah Slack (*108*) in an address given before the Western Literary Institute in 1834 commented on the general worthlessness of existing science textbooks as follows:

> Comparatively few works of the number under which the press groans, are well adapted to the capacity of the learner. The majority who make books are mere copyists. In their rage to become authors, they seize on a well-digested work, alter some of its essential features, frequently for the worse, and send it forth with the favorable review of the interested, or book-sellers, to the no small annoyance of the scholar.

The method of teaching used throughout this period was predominantly that of assigning material in the textbooks and of hearing the pupils orally repeat the same material. Many of the early textbooks were written in the form of a catechism. And until after the middle of the century chemistry textbooks contained numerous questions at the bottom of the pages or in the appendixes. These questions were usually purely memoriter and were often trivial. No independent thinking on the part of the pupils was stimulated.

In some of the larger schools the textbook was supplemented by demonstrations. Many of the early school announcements reported the use of apparatus (*109*). By the middle of the century chemical demonstrations were fairly common, but they were largely of the "trick" variety and were

not closely correlated with the subject matter; they were interesting and startling, but had little pedagogical import.

Lack of money would necessarily handicap most schools in the acquisition of laboratory equipment. In 1855 the Commissioner (*110*) of Common Schools of Ohio included the following statement in his report:

> Judging from the large number of requests for chemical and philosophical apparatus, . . . it is believed that, prior to the enactment of the present school law, very few schools in the State were furnished with these indispensable articles for visible illustration and experiment.

Three years later the superintendent (*111*) of the Chicago schools reported:

> The most pressing want of the high school that still remains, is a supply of suitable apparatus for illustration and experiment in the various departments of science.

Later, when laboratory equipment was acquired, a sign was placed in the science room with the inscription, "*Pupils must not handle the apparatus*" (*112*).

VI

During the second period the dominant aim for teaching high-school chemistry was that of mental discipline. The patronizing attitude adopted during the earlier decades by many teachers of the classics toward their colleagues in science was due in part to a belief that a disciplinary value adhered only to a study of the ancient languages. As a means of achieving this objective the laboratory method of teaching was introduced into high-school chemistry. The new aim was expressed in 1880 by Professor Frank W. Clarke (*113*) as follows:

> The sciences from an educational point of view have merits of their own unlike those of other studies. They are intended not only to give mental discipline, but also to train the faculty of observation and to teach the scholar the experimental method of grappling with unsolved problems. To accomplish these purposes . . . the beginner in chemistry tries simple experiments.

The improved status of the science of chemistry to a great extent conditioned the chemistry courses of the high schools. By the middle of the nineteenth century the discovered facts of chemistry were organized about great laws and theories; the technics of scientific discovery were well established. Textbook writers were more frequently college professors of chemistry. After the passing of J. Dorman Steele there were few, if any, omniparous authors, such as Comstock and Lincoln in the earlier decades.

The improvement in the high-school texts was accompanied by some disadvantages. There was an observable tendency toward formalization and standardization. The textbooks became less superficial, but at the same time less interesting and less vitally related to the pupils' environ-

ment. Textbook authors who were scientists tended to adopt a logical system of organization; this organization was not necessarily "psychological," in the sense that it was the one best adapted to the learning processes of the pupils. And in making high-school chemistry more "scientific" textbook writers and teachers often made it more difficult. Much more intelligence on the part of the pupils was required to comprehend the organization, the theories, the mathematical problems, and the great generalizations of the chemistry of the nineties than was needed to understand the simple, often anecdotal, material of the earlier textbooks.

The laboratory method of teaching chemistry in American high schools seems to have been due to a number of university professors who exercised an influence on the schools. They in turn were influenced to a great extent by European methods of science teaching.

The moving spirits in the revolution in the technic of chemistry teaching were mainly those who had come under the influence of Baron Justus von Liebig. In 1826 Liebig became Ordinary Professor of Chemistry at the University of Giessen. Here he organized the first educational laboratory in chemistry (*114*). Students streamed into the Giessen laboratory from almost every civilized country and went forth to spread the new gospel—the gospel of research.

Among the American scientists who studied under Liebig was Wolcott Gibbs. Gibbs also worked under Rammelsberg and Rose in Germany and under Laurent, Dumas, and Regnault in France. From the German group he imbibed the spirit of research; and he carried it back to America (*115*). In 1863 Gibbs was elected to the Rumford Professorship of the Application of Science to the Useful Arts at Harvard and to the directorship of the laboratory at the Lawrence Scientific School. Here his graduate students aided him in scientific investigations. He gave no examinations; he merely watched the students at work. Probably more than any other man, Gibbs introduced into America the German concept of research as a means of chemical instruction (*116*).

Not that Gibbs was the first disciple of Liebig to teach in American universities. John L. Smith had studied under the German master and had introduced research into the University of Virginia and the University of Louisville (*117*). Gibbs' predecessor in the Rumford professorship, Eben Horsford,* worked in the Giessen laboratory from 1842 to 1846 (*119*).

From a popular standpoint the most influential advocate of the new method was Josiah P. Cooke, Erving Professor of Chemistry and Mineralogy at Harvard from 1850 to 1894. Cooke fought for new methods of teaching chemistry and for putting the sciences on an equality with the

* One writer claims that the first laboratory instruction in America was given by Horsford at the Lawrence Scientific School in 1848. With the exception of that given at Rensselaer School this may be true (*118*).

classics (*120*). He induced the faculty of the college to accept an elective course in qualitative analysis to be taught in the laboratory by the experimental method. Having taught himself by means of a laboratory (*121*), Cooke recognized its value.

Another important advocate of the laboratory method who should be mentioned in passing was Frederick A. Genth. After studying under Liebig and other eminent German chemists, he opened in 1848 an analytical chemical laboratory in Philadelphia; here he instructed special students. From 1872 to 1888 Genth taught at the University of Pennsylvania (*122*).

In the high schools chemistry was the first science to make any extensive use of the laboratory method. As early as in 1846 Benjamin Silliman, Jr., made a plea for chemistry, "as a study peculiarly fitted to train the mind to a methodized and logical habit of thought" (*123*). At an institute held in 1870 by the Northern Eastern Ohio Teachers' Association instruction was given in methods of teaching chemistry. Laboratory experiments and the solving of chemical problems were significant features of the methods recommended (*124*).

In the decades following 1850 high schools here and there began to instal laboratory equipment and to make use of it as a method of teaching chemistry. By 1880 the new method was used in a considerable number of the larger schools. The methods of teaching chemistry employed in that year by schools replying to a questionnaire sent out by the United States Commissioner of Education (*125*) are indicated in Table IX. It will be

TABLE IX

Number and Percentage of High Schools Using Various Methods of Teaching Chemistry in 1880

	Cities 7500 or over		*Localities Smaller than 7500: Private Schools*	
	No.	*%*	*No.*	*%*
No. schools reporting method	129		296	
Elementary laboratory	46	35.7	58	19.6
Demonstrations only	74	57.4	166	56.1
Textbook work without experiments	9	07.0	72	24.3

noted that the lecture demonstration was still the predominant method of teaching chemistry; also that the size of the school was a significant factor. The majority of the schools not replying to the questionnaire probably lacked apparatus.

With the changes in the methods of teaching chemistry went the changes in the status of the science itself; chemistry was not only becoming better organized, but it was also expanding at a remarkably rapid rate. The great expansion in the subject matter over that of the early decades is evidenced by the number of textbooks appearing after the middle of the century. The schools and colleges replying to the United States Commissioner's

questionnaire of 1880 reported 204 different chemistry textbooks actually in use (*126*). Eighty-seven of these were in general chemistry; the rest were distributed in fourteen special divisions of the science.

Concomitant with the expansion in chemical knowledge was a change in the character of material included in high-school textbooks of chemistry. Hurst in his examination of fifteen high-school textbooks of chemistry covering the period from 1873 to 1924 found several significant trends in the character of the content. A consistent increase in the amount of space given to laws and theories was one of the most obvious trends. Whereas a textbook published in 1873 devoted only 1.2 pages to laws and theories, one published in 1924 contained 32.5 pages (*127*). Hurst also found a consistent increase in the number of chemical elements mentioned and a general increase in the latter part of the period in the number of mathematical problems and of equations (*128*).

An examination of the textbooks published after 1880 reveals not only an enriched content and a more logical organization, but also that authors were conscious of the disciplinary aim. One of the most influential textbooks in the early part of this period was Ira Remsen's "Elements of Chemistry" (1887). In the 242 pages of the text proper 132 experiments were expected of the pupil. There was no hint of the "chemistry of common things" in the experiments or descriptions, and the author clearly advanced the disciplinary objective in his preface (*129*).

By the end of the century the concept of mental discipline overshadowed every other objective in high-school chemistry; the laboratory in many cases almost entirely superseded the textbook. Many teachers cared not how their pupils liked chemistry, provided only their minds were "trained." And so one finds such textbooks as that of Muir (1904), in which the author (*130*) said:

> The objects of this book are: to present some of the fundamental facts, generalizations, principles, and theories of chemistry, lucidly, methodically, and suggestively; to train the student in a few of the methods of investigation and reasoning which have been used in the past, and some of the methods which are used today, for discovering and coördinating the connexions between the properties and compositions of systems of homogeneous substances; to attempt to lay the foundations of chemistry in such a way that the student may be prepared for going more deeply into the science if he wishes to do so.

That many pupils might not wish to go more deeply into the science after such an introduction does not seem to have occurred to the author.

VII

The increasing formalization and standardization was fostered by the increasing subordination of the high school to the college. Before 1870 no sciences were accepted for entrance credit by any American college. Ap-

parently the first science to be required for admission was physical geography: Harvard and the University of Michigan required it in 1870 (*131*). Candidates for the classical course at Harvard in 1876 were required to pass an examination in one of the following subjects: (*a*) botany; (*b*) physics and chemistry; (*c*) physics and astronomy. Physics or chemistry was required for admission to special scientific courses in the Lawrence Scientific School somewhat earlier than for admission to the classical course (*132*).

By 1879 a number of colleges had included chemistry and other sciences in their list of entrance requirements. Out of forty-four colleges studied in that year by Nightingale only five required chemistry (*133*). Natural philosophy, physical geography, and physiology were much more frequently required.

Although high-school chemistry seemed well on the way to complete recognition by the colleges, there continued to be in the latter institutions some dissatisfaction with the science taught in the schools. In response to a report by President Charles W. Eliot, Harvard initiated a movement that has profoundly affected secondary school science. In 1887 Harvard (*134*) for the first time required for admission a "course of experiments in the subjects of mechanics, sound, light, heat and electricity, not less than forty in number, actually performed in school by the pupil." Thus, officially, perhaps, began the college pressure on the high-school science course. The laboratory from that time on must do more than teach the pupil science; it must discipline his mind.

Some colleges extended their control over the high-school science curriculum by certification of schools rather than by examination. The University of Michigan adopted such a plan in 1870 (*135*); the University of Illinois adopted a similar plan in 1887 (*136*).

Still more effective as agents of standardization were the regional accrediting associations which were organized in the eighties and nineties (*137*). Out of the Association of Colleges and Secondary Schools of the Middle States and Maryland grew the College Entrance Examination Board (*138*). The influence of this body was particularly potent in the Northeastern States. As late as in 1924 Segerblom found that the average number of laboratory experiments performed by pupils in eighty New England high schools was fifty-two. Only eleven schools required under forty experiments and fifteen required exactly forty. The investigator (*139*) significantly remarked:

> The influence of the College Board is rather evident here, since the Board requires 40 experiments.

The high-school teachers themselves apparently were willing to be dominated by the college. The increasing employment in the high schools of

college-trained teachers would foster the spread of college aims and college methods in the lower schools. State teachers' associations recognized the existence of the tendency and encouraged it (*140*). And about the same time the University of the State of New York began its policy of regents' examinations (*141*), a policy which has made the high schools of that state the most standardized of any in the country.

A good exemplification of the various tendencies existing in high-school chemistry during the nineties and at the same time a stimulus to an accentuation of the tendencies were the reports of the two great committees of the National Education Association—The Committee of Ten and the Committee on College Entrance Requirements. Both committees accepted the disciplinary aim of secondary education and took it as the point of departure (*142*). Both advocated courses of study in chemistry that were essentially college preparatory courses.* College professors, in fact, predominated in the committees and in all sub-committees. Both committees emphasized in chemistry teaching the importance of a logical organization and of the experimental method. The standardizing influence of these reports was incalculable.

The report of the Committee of Ten included a list of 100 experiments in chemistry. It was asserted that the list was tentative and suggestive rather than prescribed; that it was followed by a large number of teachers, however, seems probable. It contained experiments on the preparation and properties of oxygen, hydrogen, nitrogen, ammonia, ammonium hydroxide, ammonium salts, halogens, acids of halogens, oxides of carbon and nitrogen, nitric acid, sulfuric acid, sodium hydroxide, potassium hydroxide, calcium hydroxide, salts of the common metals, and mixtures and compounds. There were included tests for the common metals and illustrative types of chemical action. Experiments of both a qualitative and quantitative nature were found in the list, but there were none in organic chemistry (*144*).

VIII

Although college domination of high-school chemistry has continued in many schools until the present time, a reaction began to take place during the first and second decades of this century. This included to varying degrees reaction against college domination, against too much uniformity and standardization, against the lack of vital relationship between chemistry instruction and every-day life, against the dominance of the laboratory, against the over-emphasis on mathematics, against the disciplinary aim of education, against the logical organization of the subject matter, and

* The special committee on chemistry of the Committee on College Entrance Requirements reported that "The line of thought to be developed in connection with the experiments performed . . . is well given . . . in the Harvard Requirements in Chemistry" (*143*).

against an arid and uninteresting presentation of it. Pupils were rebelling at the dry bones set before them.

Evidence of discontent with the existing instruction was revealed in periodical articles, in speeches before educational gatherings and in such significant reports as that of the Commission on Reorganization of Secondary Education. The reaction, of course, was not a clean-cut movement. Some high schools have continued to offer the same type of science that was offered thirty years ago.

A particularly significant tendency within the past two decades—in high-school chemistry as in high-school education as a whole—has been the critical examination of existing objectives and the formulation of new objectives. The earlier objective of mental discipline to a large extent has been abandoned; new ones have been formulated that are more consistent with psychological knowledge and with the democratic conception of secondary education.

The most influential statement of objectives was probably that made by the Commission on Reorganization (*145*). Similar formulations of new aims for high-school chemistry were made in 1920 by the Central Association of Teachers of Science and Mathematics (*146*) and in 1927 by the Committee on Standards for Reorganization of Secondary-School Curricula of the North Central Association (*147*). There is no evidence of the extent to which the newer objectives have actually modified the instructional practices of the teachers. But a recent *Research Bulletin of the National Education Association* (*148*) contained the following statement:

> A review of recent course of study bulletins in high-school science shows that science teachers are coming to realize that science in school must be made a way of looking at the world, a way of dealing with problems, a way of enjoying life, a method of progressive adjustment.

Although objectives have been and must continue to be derived philosophically, there has been an increasing trend toward submitting problems of the chemistry curriculum and of methods of teaching to the test of objective research. Important committees dealing with secondary education within the past two decades have included in their membership a much larger proportion of technical educators than those of the nineties. The interest of chemistry teachers in the realistic solution of their problems was evidenced by the establishment in 1924 of the JOURNAL OF CHEMICAL EDUCATION.

The Committee on Science of the Commission on Reorganization made an effort to avail themselves of such research studies as had been made. They carried on their work for over seven years by means of discussions, correspondence, and formulations of preliminary reports (*149*). The Committee on Chemical Education of the American Chemical Society based its 1924 re-

port on the correlation of high-school and college chemistry on 30,000 criticisms from teachers and chemists (*150*). The Special Committee on the Place of Science in Education appointed by the American Association for the Advancement of Science expressed the hope that its 1927 report would stimulate further specific investigations in the field of science teaching (*151*).

During the last decade a number of studies have been made which attempted to derive objectively the curricular material of high-school chemistry courses or to determine the most effective methods of teaching (*152*). In addition, many classroom teachers of chemistry have adopted an experimental attitude toward their own instructional problems and many administrative officers have experimented with the courses of study in science (*153*).

As a result of the social and economic forces affecting the American high school and as a result of the enlarged conceptions of the aim of secondary education the high school has become less of a college preparatory institution. High-school chemistry in consequence has tended to become more informational and utilitarian in character. The needs and interests of the pupils and the demands of an industrial civilization have more and more conditioned the type of chemistry taught in the high schools. This trend has apparently been limited largely to the more progressive schools and instructors.

As early as in 1910 the High-School Teachers' Association of New York City recommended the acceptance of high-school graduation from an accredited high school as satisfying the entrance requirements of any college (*154*). They proposed that college entrance credits should be granted for household and advanced chemistry. During the same year Whitsit (*155*) pointed out that

> There [was] a tendency to introduce more chemical technology than was given in the older courses to satisfy the ideal of providing a means of earning a living.

Many recent chemistry textbooks reveal an attempt to make the work more practical and more closely correlated with the every-day life of the pupil. Such titles as "Practical Chemistry," "Chemistry in Everyday Life," "Chemistry and the Home," and "Applied Chemistry" are typical of the new movement. The multiplicity of recent inventions of popular interest have been capitalized by many authors.

The science committee of the Commission on Reorganization took a rather radical stand on the question of organization of the chemistry course. They recommended a problem form of organization, coördinated with and built upon the environment of the pupil (*156*). The committee of the American Chemical Society took a more moderate position. They recognized college requirements to a greater extent and listed topics for a stand-

ard minimum course. A number of practical topics were introduced for supplementary work (*157*).

The plan of including two sections in the textbook—the first containing the topics essential to a basic understanding of the science of chemistry and the second containing topics of more direct utility—seems to be becoming the most common plan adopted by progressive authors.

A number of the authors have seriously attempted to utilize a psychological approach to the subject. The unit or problem type of organization has apparently been employed most effectively. Further to harmonize chemistry instruction with the best educational procedures some textbook writers have introduced first the study of the familiar substances, water or metals, rather than the unfamiliar oxygen.

The recent trends in methods of teaching have involved some criticism of the laboratory method. The laboratory has been retained; but, just as the recent content of the course has tended to approach the informational and practical science of the middle of the nineteenth century, so the lecture demonstration has also tended to increase in popularity. Bowers and Brown in 1924 apparently found that the amount of time given to individual experimentation had increased since the beginning of the century (*158*). But several objective studies have indicated that the laboratory, despite its greater expense in time and money, produces no more effective results than the demonstration (*159*). The Special Committee on the Place of Science in Education concluded that the demonstration was worthy of wider acceptance than it was customarily granted as a method of instruction (*160*). Certainly the laboratory notebook is less of a fetish than it was at the beginning of the century. Some textbook writers have merely left blanks in the textbook to be filled in by the pupil.

New methods which were not widely used in the nineteenth century have been introduced to vitalize the teaching of chemistry. These include such technics as the project method, visits to industrial plants, chemistry clubs, dramatics, outside readings, and special reports. Sectioning classes on the basis of intelligence tests and the use of standardized tests in high-school chemistry have likewise been recent innovations.

Another phase of modern chemistry teaching has been a definite effort to humanize the subject. The introduction of historical and biographical material has been one method used for effecting this end. On the part of some textbook writers such efforts have been superficial and almost condescending. The use of biographical material was recommended by the Special Committee on the Place of Science in Education (*161*) and by the Commission on Reorganization (*162*). The most successful humanization so far, however, has probably been achieved by the use of a more interesting style and of more interesting illustrations. The introduction in illustrations of actual human hands manipulating apparatus—a procedure com-

mon in textbooks of the early period—has again been adopted by textbook writers.

None of these more recent trends have affected alike all the teachers and textbook writers of high-school chemistry. In fact an increasing diversification of content and methods of teaching seems to have been an observable tendency. There has been within the past two decades an increasing desire to avoid standardization and to adapt the chemistry in any high school to the needs of the community and to the needs of the individual pupil. Somewhat general agreement has been reached that there are minimum essentials in high-school chemistry. But these can be taught in various ways to attract the interest of different pupils. And with the rich supply of available supplementary topics there is no valid reason why any high-school pupil should find chemistry a barren or an arid subject.

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Museums in Motion. A new method of visual instruction in science and technology is in process of development in the United States, based on the plan of the famous Deutsches Museum at Munich. This museum is unique among the museums of the world in that the illustrative installations are shown, where possible, in operation. There are pushbuttons and levers everywhere, and visitors are encouraged to use them to place the various machines in motion. For example, Puffing Billy, the first locomotive, is shown in exact replica. Instead of steam, compressed air drives the pistons and wheels; and the visitor may start the locomotive in action simply by pushing a button.

Such exhibits appeal to the visitor much more than any inactive models or the most detailed photographs or diagrams. They are easily understood by one totally unfamiliar with science or technology. Moving apparatus has the same advantage as appertains to the moving picture, which is infinitely superior to the ordinary lantern slide as an agent for education.

Four cities in the United States have already taken steps to inaugurate industrial museums. The first was the Newark Museum, planned by the late John Cotton Dana, of the Newark Public Library, and designed to show more especially the industrial activities of that busy community. Through the generosity of one of Newark's merchants, a beautiful building has been erected to house the growing collections.

In New York, inaugurated by the bequest of the late Henry R. Towne, there has been established in that city the Museum of the Peaceful Arts. This museum occupies temporary quarters in an office building; it is the hope that the collections there exhibited will draw the attention of other philanthropists, and thus obtain endowments which will make it possible to carry out on a large scale the provisions of the will of the founder.

In Philadelphia, the museum is to form part of that venerable institution, the Franklin Institute. Plans have been drawn, and a site chosen, for the Benjamin Franklin Memorial and Franklin Institute Museum, in the vicinity of the Philadelphia Public Library's new building. A planetarium, the gift of Mr. Samuel Fels, is to be installed in this new museum.

In Chicago, Mr. Julius Rosenwald is fathering the Museum of Science and Industry. This institution is making detailed study of plans. It is hoped that the museum may show, not only how a machine works, but the sociological results which follow. Not only will the cotton gin be shown in operation, but it will be shown how its advent affected the whole life of the South, led to the extension of slavery, and finally to a prolonged civil struggle. The Chicago museum will ultimately be housed in the old Fine Arts Building of the World's Columbian Exposition, which will be rebuilt entirely from permanent materials, and will furnish some 400,000 square feet of floor space for exhibition.

Other industrial museums are contemplated at other places. When these large industrial museums get into operation, they will undoubtedly be thronged like the Deutsches Museum at Munich, which boasts a million visitors every year.—*Ind. Bull. of Arthur D. Little, Inc.*

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THE EMPLOYMENT PROBLEM OF 1931

D. H. KILLEFFER, BUREAU OF EMPLOYMENT OF THE CHEMISTS' CLUB, NEW YORK CITY

Unemployment as it now affects the chemical profession is briefly discussed. Particular emphasis is placed upon the part played by the applicant in securing employment in trying times like the present and a number of points to be especially observed in applying for a job are noted.

. . . . . .

Of all the side lights on the present industrial depression, one of the most interesting and important is the revelation that so many professional men and women do not know how to go about finding work. That there is a proper technic for doing this many do not realize and often after finding a proper opening some fault of technic allows it to slip through their fingers. When opportunities are so scarce and applicants so many as at present the fine points of approach and negotiation are of ruling importance. This paper is being written to set forth a few of the writer's observations along this line for such benefit as they may be to those interested, and particularly to the teachers of chemistry on whom rests the important task of preparing boys and girls to make a living from this profession.

It is quite apparent that much of the gloom about unemployment among chemists and chemical workers generally is unwarranted by a careful study of the facts. Although in many individual cases the situation is necessarily very serious, a careful survey of the field reveals the fact that this profession has suffered much less in proportion than others. Based upon estimates including a most generous factor of safety, it seems probable that less than one in ten, and possibly not more than one in twenty, of those sufficiently trained in chemistry to be considered members of the profession are at present out at work. This compares with a figure published by government agencies to the effect that approximately one in seven wage earners in the country at large are unemployed. In the engineering professions unemployment is said to be at a considerably higher rate than the general one.

Whatever comfort may be gained from such statistics, one must admit that the old sophistry of "accepting a position" is distinctly an anachronism and that any one out of work now will be glad to "get a job."

Unquestionably the present is a time when each person must put his best foot forward. Employers are looking for ways to improve their organizations and to strengthen weak spots. New work is very rare. In this situation experience bargains are being eagerly sought and the man with special experience has a pronounced advantage over one not so endowed.

From the employer's viewpoint, the large number of job seekers is both an asset and a liability. An asset, because he is quite sure to be able to find exactly what he needs. A liability, for the reason that even the most

guarded announcement of his wishes floods him with applicants who use his time and wear out his patience. Obviously, his best method of avoiding this liability is to turn his problem over to a recognized organization in whom he has faith to conduct the preliminary sorting of applicants for him. For this purpose the Bureau of Employment of the Chemists' Club, operated by chemists for themselves, offers itself as a ready help.

Obviously, with employers turning to an agency of this kind it is of special advantage for the unemployed man of experience to have his credentials where they can be immediately available as a means of securing introductions to possible openings.

However, the applicant learns of openings, whether from advertising, friends, or through other means, his next step, his first contact with the prospective employer, is of greatest importance. A surprisingly large number seem to adopt the attitude that employers are eager to put them remuneratively to work and that it is merely necessary to let employers know they are open to offers to be handed a position of nothing less than president on a golden salver. Of course, a little thought on the subject will lead to the inevitable conclusion that employers are human and that they are inclined to devote at least as much thought and time to hiring a man as they would to the purchase of a suit of clothes or a hat, and quite often much more. While there are a few people in this world whose very name stands for them and calls to mind many accomplishments, the vast majority even of chemists must discard diffidence and realize that employers are vitally interested in knowing what they are about to buy for the salary they expect to pay.

After all, an employer is more interested in what he will get than in the salary he must pay. Applicants for employment, on the other hand, frequently overlook this and by setting salary considerations first place themselves and their possible value to employers so far in the background that they fail to get the consideration they deserve. Witness the horrible example of the man who called an employer by telephone and immediately asked without preliminary what salary was offered only to be told curtly "none to you."

One frequently finds that letters, written in lieu of personal interviews, omit essential details while the inconsequential details of the applicant's hope to be president some day are spread over page after page. Of course, one's ambitions are important but one's history even in minute detail is more so for it allows the reader to judge what really is essential, one's reasonable hope of achieving them, for one can only judge the future by the past.

The selection of what is essential to tell about oneself is a real problem and one on which too much thought cannot be spent. It is usually far better to be quite frank about things than to allow some embarrassing bit

to be dug up later and become too prominent to be explained away. If one can learn anything of the prospective employer's wishes and plans the problem of selection and presentation of data is much simplified. If not, it is a safe rule to bear in mind that an employer has problems of his own and that his interest, if any, in you is based on the hope that you can help him solve some of them.

Often applicants are inclined to be too egotistical or too modest, and either may be as bad as the other. The line between good salesmanship and egotism is as hard to define as the one between modesty and diffidence, yet both must be carefully drawn by the individual himself. Like most distinctions of the kind, each person must drawn them for himself for after all it is the way these things are done that make up one's personality.

To sum up these random thoughts for the jobless:

1. Be sure possible employers know you are looking for work and that your record is available to them when they want it.
2. Remember a prospective employer is more interested in what you can do for him than in anything else.
3. Be sure your story of yourself accurately represents you.
4. Don't create skeletons in your closet by trying to hide things which may later come up to plague you.
5. Remember that if you have no confidence in yourself, no one else can have.
6. Modesty is a becoming virtue but must be displayed in moderation.
7. Never be over-egotistical. You will surely be found out.
8. Study your prospective employer's problems and keep them first in your mind when presenting your own case.
9. Few men ever get a job solely because they need or want one.
10. An employer is primarily interested in getting full value for the wages he pays you. Advancement must be earned, whatever expectations either the employer or the employee may have at the start.

These suggestions seem to be wholly self-evident and axiomatic but the number of even professional workers who totally disregard such simple truths is astounding. Careful following of them will save much disappointment in so seriously competitive a time as the present.

Drawing No Aid to Science Students. The drawing of specimens in laboratory notebooks, a time-honored method of impressing the structure of plants and animals on the mind of the elementary biology student, has been tried and found wanting by Lourene Taylor, instructor in plant biology at the University of Oregon.

The trial was made on 178 students, 91 of whom made their own drawings. For the others ready-made drawings were provided which the student had merely to label correctly. It was found that the students who did not draw got along a little better on the average than those who labored with the original drawings.—*Science Service*

A FRESHMAN EXPERIMENT? THE REACTION OF MAGNESIUM WITH ACIDS*

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In accordance with the older definition of acids one would say that the reaction of magnesium with acids is a reaction between the metal and the hydrogen ions. This problem is discussed from the viewpoint of the Brönsted definition of an acid and it is shown that while the reaction in dilute aqueous solutions of strong acids is with the acid H_3O^+, the predominant reaction in aqueous solutions of weak acids is not with the hydrogen ion H_3O^+ but with the other acids present. Experimental evidence is submitted to show that magnesium reacts with molecular chloroacetic, acetic, formic, and glycollic acids and with the ammonium ion, which is an acid. In solutions of low hydrogen-ion concentration the reaction with the hydrogen ion is negligible. It is pointed out that these results are not confined to the metal magnesium and that this point of view may be a fundamental one in the study of corrosion. On the grounds that the new ideas lead to simplicity in one's concept of acids and bases in non-aqueous and in aqueous solution, and to progress in the field of homogeneous catalysis and in the study of the rate of solution of metals in acids, a plea is made for the teaching of acids and bases from the new point of view.

. . . . . .

The present paper is an attempt to bring to the attention of the teachers of chemistry the modern conception of acids by showing how this new viewpoint modifies our ideas on the rate of solution of metals in acids. If we were asked what happens when magnesium is added to a dilute aqueous solution of hydrogen chloride, we would probably reply that the metal reacts with the hydrogen ion and hydrogen is given off. If the same question were asked concerning a weak acid we would say the same and add that, as the hydrogen ions are removed, more appear, due to further ionization of the weak acid. An acid would therefore be a substance which forms hydrogen ions in aqueous solution.

Let us now consider the more recent definition of an acid (*1*). Brönsted defines an acid by the formal equation

$$A \rightleftharpoons B + H^+$$

where A is an acid, irrespective of the charge, B is a base, and H^+ is a proton. In accordance with this definition the hydrogen ion, H_3O^+, is an acid in aqueous solution, but we have other acids in aqueous solution such as the uncharged formic acid molecule or even the ammonium ion.

$$H_3O^+ \rightleftharpoons H_2O + H^+$$
$$HCOOH \rightleftharpoons HCOO^- + H^+$$
$$NH_4^+ \rightleftharpoons NH_3 + H^+$$
$$H_2O \rightleftharpoons OH^- + H^+$$

* Delivered before the Division of Chemical Education at the 81st meeting of the A. C. S., Indianapolis, Indiana, March 30 to April 3, 1931.

Of course, the ammonium ion is quite a weak acid since it does not give up its proton very readily. Water is both an acid and a base as indicated above, and the hydroxyl ion is only one of many bases. This definition furnishes a general basis for consideration of acids and bases in aqueous and non-aqueous solution and has been a very profitable viewpoint in the study of homogeneous catalysis (*2*).

In aqueous solution there exists a double acid-base equilibrium, due to the fact that the solvent itself is both an acid and a base. The reaction accompanying the solution of hydrogen chloride in water may be written

$$\underset{\text{acid}}{HCl} + \underset{\text{base}}{H_2O} \rightleftharpoons \underset{\text{acid}}{H_3O^+} + \underset{\text{base}}{Cl^-}$$

Hydrogen chloride is such a strong acid that it readily gives up its proton to the base, water, the equilibrium being displaced practically completely to the right. The acid present besides water in a hydrochloric acid solution is the ion H_3O^+ or, as we shall call it, the hydrogen ion. The concentration of the proton is so small as to be of no kinetic significance. The case above is a general illustration of the state of affairs existing when any strong acid is dissolved in water and explains why all strong acids appear to be of equal strength in dilute aqueous solution.

Let us now consider a weak acid. When formic acid is dissolved in water we have

$$\underset{\text{acid}}{HCOOH} + \underset{\text{base}}{H_2O} \rightleftharpoons \underset{\text{acid}}{H_3O^+} + \underset{\text{base}}{HCOO^-}$$

The equilibrium is not displaced far to the right as in the case of a strong acid, so we have, besides water, two acids in appreciable concentration—first, the acid H_3O^+, and second, HCOOH. The problem is to determine whether the magnesium reacts with the acid H_3O^+, with the acid HCOOH, or with both.

Our first experiments were so striking that they are worth describing. The experiments were carried out by rotating a cylinder of magnesium in a known volume of the solution and measuring the rate of evolution of the hydrogen. Our first experiment was with 0.01 *M* hydrochloric acid solution, that is to say, with a solution 0.01 *M* in hydrogen ion. Hydrogen was evolved at a rate of 0.5 cc. per minute. We then made up a buffer solution 1.7 *M* in formic acid and 0.1 *M* in sodium formate. The hydrogen ion concentration of such a solution is approximately 0.005 *M;* if the reaction were with the hydrogen ion alone a rate of about 0.25 cc. per minute would be expected. The experiment was carried out with the same piece of magnesium and the rate of evolution of gas was much too rapid for measurement, being of the order of 100 cc. per minute. From this we concluded that the reaction might be partly with the molecular formic acid unless the formate ion or the change in medium had some remarkable effect.

The systematic experiments, carried out with Mr. Rushton (*3*), are given below. All experiments were performed at 25°C. Figure 1 shows the proportionality between the rate of reaction and the hydrogen ion for dilute solutions of strong acids. The results also indicate that the electrolyte (salt) effect is small in this case.

Figure 2 summarizes the experiments with formate–formic acid buffers.

The rate of reaction is proportional to the formic acid concentration. In each series the H_3O^+ concentration was kept practically constant by diluting the buffer with sodium chloride solution so that the equivalent salt concentration was kept the same. According to the law of mass action the

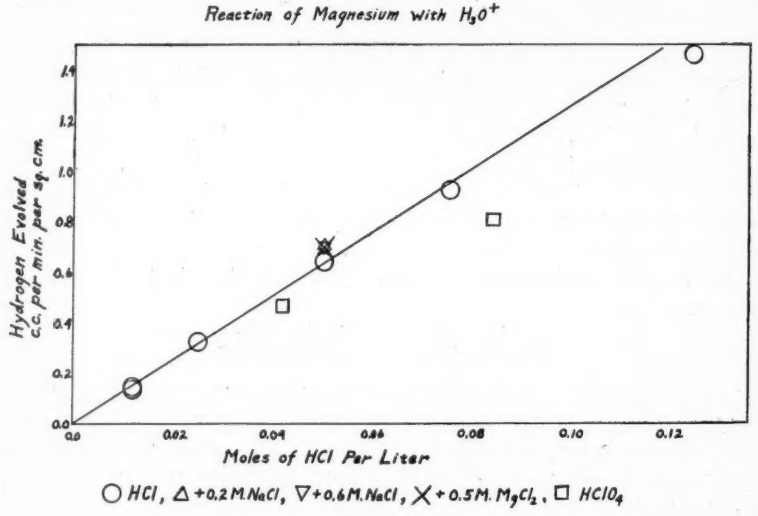

FIGURE 1

hydrogen-ion concentration of the buffer solution is given by the equation

$$[H_3O^+] = K_c[HCOOH]/[HCOO^-]$$

where the brackets represent concentration and K_c is the classical dissociation constant. Now K_c is not a true constant but depends upon the concentration of electrolyte and to some extent upon the individual electrolyte present. By keeping the electrolyte concentration fixed, K_c is sufficiently constant, however, so that the hydrogen-ion concentration may, for our purposes, be considered constant. From the fact that the hydrogen-ion concentration in the second series is 75 per cent less than in the first, and from the fact that the best line through the points passes practically through the origin we may conclude that the reaction between the H_3O^+ and the magnesium is negligible at these concentrations of hydrogen ion.

Figure 3 shows the results with acetate–acetic acid and with glycollate–glycollic acid buffer solutions.

In both cases the rate of reaction is proportional to the concentration of the molecular acid. The rates with glycollic acid are faster than with acetic as might be expected from the fact that glycollic acid is a stronger acid than acetic, *i. e.*, it gives up its proton more readily.

Figure 4 gives the results with chloroacetate–chloroacetic acid buffers. Again proportionality between the rate and the acid concentration is established.

Magnesium also reacts with the ammonium ion but the results do not

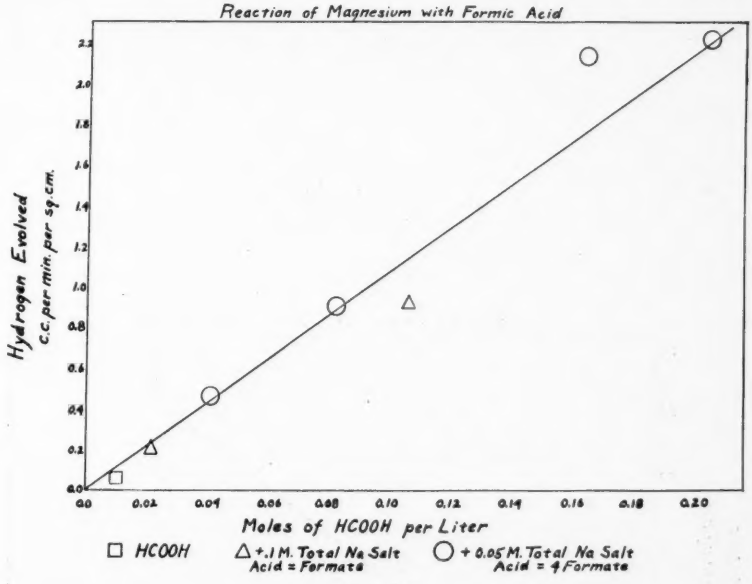

FIGURE 2

show good proportionality when experiments in ammonia–ammonium chloride buffer solution are considered. The rate seems to decrease as one increases the concentration of the ammonia. This effect has also been observed by Bekier and Zablocki (*4*). This specific effect may be due to the formation of a film of magnesium hydroxide. The reaction of the metal with water has not been investigated but it is well known that magnesium does react with water at high temperatures.

The next step is to see if there is any relationship between acid strength and the velocity constant. Velocity constants for the experiments described were calculated by means of the equation

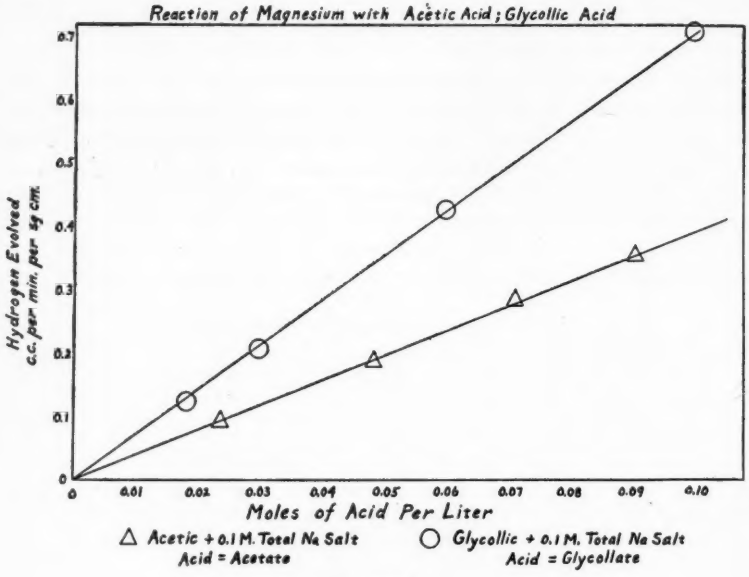

FIGURE 3

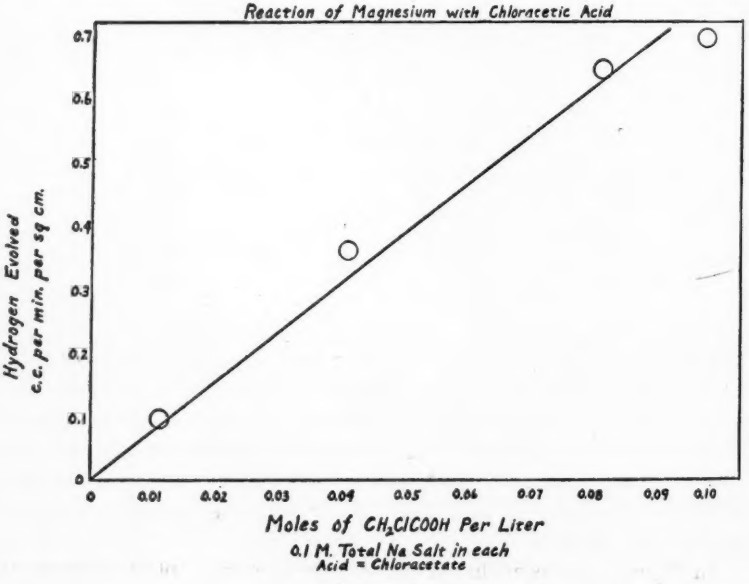

FIGURE 4

$$k = \frac{2.3V}{St} \log \frac{c_0}{c_t}$$

where V is the volume of the solution in cc.; S, the surface of the magnesium in cm.^{2}; t, the time in minutes; and c_0 and c_t are the initial and current concentrations of acid, respectively. In the second column of Table 1 are given the average values of the velocity constants; in the third column are a number of velocity constants obtained by Tarle (*5*).

TABLE I

The Rate of Solution of Magnesium in Acids

Acid	*Velocity constant, K. and R.*	*Velocity constant, Tarle*	*K_a acid diss'n constant*
Hydrogen ion, H_3O^+	1.20	1.23	56[a]
Formic acid	0.460		2.1×10^{-4}
Acetic acid	0.324	0.390	1.8×10^{-5}
Glycollic acid	0.375		1.5×10^{-4}
Chloroacetic acid	0.390		1.6×10^{-3}
1,2,5-Dioxybenzoic acid		0.774	1.1×10^{-3}
β-Resorcylic acid		0.511	5.2×10^{-4}
Tricarballylic acid		0.489	2.2×10^{-4}
Ammonium ion	0.0984		3.2×10^{-10}

Although an acid is defined by the equation

$$A \rightleftharpoons B + H^+$$

the acid strength of the substance, A, cannot be expressed by the equilibrium constant of the process above,

$$K_a' = [B][H^+]/[A] \qquad (1)$$

for the concentration of the proton is too small to be measurable. This constant can, however, be related to the equilibrium constant K_0 which defines the acid property of the hydrogen ion,

$$K_0 = [H_2O][H^+]/[H_3O^+] \qquad (2)$$

Dividing (1) by (2) one obtains

$$[B][H_3O^+]/[A][H_2O] = K_a'/K_0$$

the ratio being equal to the equilibrium constant for the double acid-base equilibrium. Considering the concentration of the water as constant, and transposing it to the other side, one has

$$[B][H_3O^+]/[A] = K_a'[H_2O]/K_0 = K_a$$

where K_a' is the customary dissociation constant of the acid, A. The dissociation constant may therefore be taken as a measure of acid strength in any given solvent.

In Figure 5 the logarithm of the velocity constant is plotted against the logarithm of the dissociation constant of the reacting acid, and the best

straight line has been drawn through the points. The ammonium ion point is uncertain due to the effect of ammonia, but the plot seems to indicate the same general relationship between the velocity constant and acid strength as found in certain cases of acid and basic catalysis (*6*).

These ideas do not apply to the metal magnesium only but are quite generally applicable. King (*7*) has obtained reproducible results with zinc by the addition of potassium nitrate or hydrogen peroxide to the acid solution; he has shown that zinc reacts with acids in the same way as does magnesium. In this laboratory we are investigating the reacting between amal-

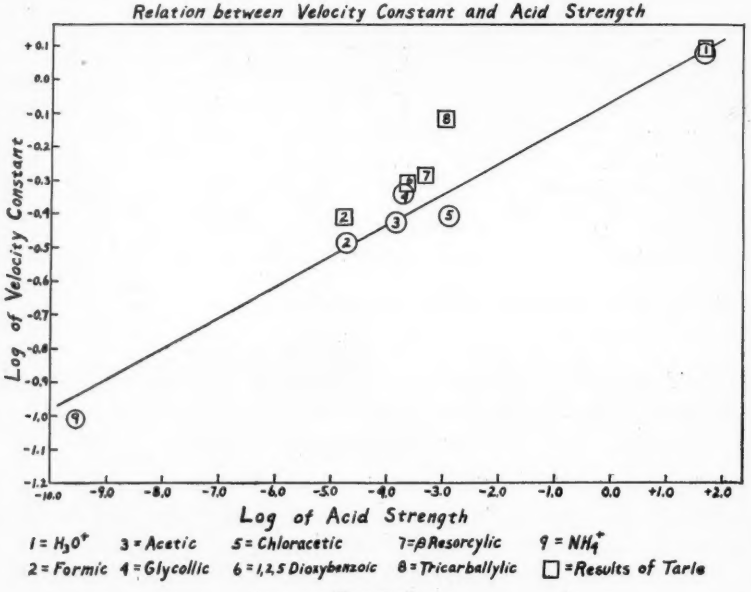

FIGURE 5

gams and acids from the same point of view with promising results (*8*). The work has also been extended to non-aqueous solutions.

An examination of the literature indicates that this conception of acids may be a fundamental and a profitable one in the study of corrosion, especially the corrosion of tin and lead.

The results with metals dissolving in acids, as illustrated above, and the results in homogeneous catalysis indicate that the new conception of acids and bases has made for progress in these fields. One might say, off-hand, that it has made acids and bases more complicated and that the old ideas are simpler and more teachable. This is not the case. The new ideas lead to simplicity in non-aqueous solution. The student who has not

learned the old ideas takes to the new ideas much more readily than to the old ideas, even in aqueous solution. I believe that teachers of chemistry should begin to teach their freshmen from this point of view. After all, chemistry today is not confined to aqueous solution.

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Many Occupations Open to Those of Low Mentality. The boy who is endowed with less mental capacity than the average of his fellows need not be barred by this handicap from successfully earning his living. Albert Sidney Beckham, of the Institute of Juvenile Research, Chicago, has brought together the findings of several investigations of the minimum intelligence levels for many occupations, and has listed those which people of various mental ages can enter with a good chance of making good.

Even the youth who has a mental age only equal to that of an average five-year-old child can do simple domestic work such as washing dishes, handle cinders, feed and fold from mangle in laundries, sandpaper furniture, and scrub and polish floors. Boys of a mental age of six can mow lawns, mix cement, handle freight, assist brick mason, and make brushes; girls of this age can crochet, weave rag rugs, and do simple laundry work.

The list of acceptable occupations grows longer with each added year of mental age. Simple carpentry can be undertaken by those seven years old mentally; painting outside and interior flat work at the mental age of eight; playing an alto horn or drums, repairing furniture, and the higher processes of shoe repairing at nine; and setting and sorting type, sign painting, farm work and dairying, and carrying mail at ten.

Boys with a mental age of eleven or twelve can be competent janitors, caretakers, or stock keepers, or they can keep a small store. Girls of the same mental age can sew the wire edges and facing in hats, do simple library work, do Italian cut work in embroidery, or power sealing in canning plants. At this mental age, too, it is possible to learn to play the first violin, cello, flute, and clarinet.—*Science Service*

Rock Falls Prevented by Cooling Mine Air. The falling of coal from the roofs of coal mines can be prevented by cooling the intake air, J. H. Fletcher and S. M. Cassidy, Chicago engineers, reported recently to the American Institute of Mining and Metallurgical Engineers. The continuous falling of roof coal in an Indiana mine during summer months, which endangered safety, hampered haulage, choked airways, and broke trolley wires was shown to be due to the high temperature and not to the high moisture content of the air. A cooling plant installed there caused greater safety improvement in comfort and efficiency, and considerable reduction in operating costs.—*Science Service*

MORE EFFECTIVE INDIVIDUAL LABORATORY INSTRUCTION IN GENERAL INORGANIC CHEMISTRY

III. THE USE OF AN ELASTIC TASK*

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The use of an elastic task, in general inorganic chemistry laboratory instruction for students with varying previous chemical training, is described. The task presented in each experiment attempts to challenge the ability of the better student while, at the same time, permitting the weak but conscientious student to accomplish an acceptable minimum requirement.

Two typical experiments are reviewed and their quantitative features are described. By means of these quantitative features, comparisons are made between the students who had, and who had not, taken chemistry courses in high school. The results considered show no significant differences between these two groups of students.

It is concluded that the elastic task is a desirable instructional feature for classes containing students of varying previous chemical training.

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The senior author has developed a method for teaching general inorganic chemistry laboratory in order to permit efficient individual laboratory instruction of students with varying previous chemical experience. One important phase of this method is the presentation to the student of an elastic task which will challenge the ability of the better student while presenting an acceptable minimum which is within the reach of the weak but conscientious student. This and other outstanding features,** together with the instructional procedure of this method, have been discussed in the first paper (*1*) of this series. In the second paper (*2*) the application of this method is presented by means of specific illustrations taken from a typical experiment. The purpose of this paper is to demonstrate that students who have had no previous chemical training can work in the same laboratory sections with students who have had high-school courses in chemistry without being handicapped by this situation.

The elastic task consists of an assignment which will offer to the more advanced students a field for indefinitely thorough study while permitting the beginning students to study the same subject matter in a more elementary way. In order to permit this, the subject matter of the course deals with the more fundamental phases of inorganic chemistry. Some of the experiments will be encountered later, in advanced chemistry courses.

* Presented before the Division of Chemical Education of the A. C. S. at the Indianapolis meeting, March 30–April 3, 1931.

** Other outstanding features are: (*a*) the required use of several references in the laboratory, (*b*) systematic reading in popular chemistry, (*c*) the length of the experiments, each requiring from twelve to eighteen laboratory hours, (*d*) written quizzes, (*e*) more instructional time for assistants and full instructional time for the instructor.

The use of the *study topics*, the *topics covered*, and the *required references* makes possible the performance of the assignment in a manner limited only by the student's ability. Students having had no previous chemistry are asked to study only a specified pair of the *required references*. Other students are expected to read more than this and are encouraged to read in the more advanced texts. As a result of this requirement, some students will study each item of the *topics covered* and the *study topics* in advanced and elementary references, while those who have had no previous chemistry will refer only to the two assigned elementary references. It will be seen that this task is, therefore, very elastic. Beginning students are not discouraged by their apparent failure to use all references because they are not expected to do so. More advanced students cover the same material, but in a manner limited only by their own capacity.

Experiments III and IV of the laboratory manual will be briefly presented, followed by a comparison of the achievements of those students who had had no previous chemistry with the achievements of those who had had earlier training in the subject. These two experiments were chosen because the writers anticipated that the greatest difference between the two groups of students would become evident at that time.

Content of "Experiment III"

The general content of the first of these experiments, Experiment III, is shown by the following outline:

Title: *The approximate determination of atomic weights by the use of the law of Dulong and Petit.*

Object: An illustration of the law of Dulong and Petit and the determination of the atomic weight of a solid element.

Topics Covered: Atoms. Molecules. Atomic weights. Atomic theory. Law of Dulong and Petit. Properties of solids. Crystal structure. Gram atomic weight. Specific heat. Use of the metric system. Use of logarithms. Graphic representation. Use of balances.

References: "Optional" or semi-popular library references and "required" references, which are available in the laboratory. The use of these references has been fully discussed in previous papers (*1*), (*2*), and constitutes one of the phases of the elastic task. Students, who have had no previous chemistry, study only specified references, while other students are urged to study topics more thoroughly in additional texts.

Apparatus and Materials: A list.

Procedure: 1. *The determination of the atomic weight of copper.*

(*a*) Theoretical discussion by the student preceding his execution of the experimental work. (*b*) Experimental determination of the specific heat of copper. (*c*) Calculation of the atomic weight of copper, using 6.4 as its atomic heat. (*d*) Recalculation of the atomic heat of copper by using its correct atomic weight and the determined specific heat.

2. *The determination of the atomic weight of an "unknown" metal according to the above procedure.*

3. *The preparation of time-temperature curves from experimental results.*

Exercises: Ten problems to be solved outside of laboratory hours and handed to the "Record Assistant" on a specified date.

Study Topics: Fifty topics taken from the "Topics Covered," the "Procedure," and a specified pair of the "Required References." These are listed in topic form to further student study prior to quizzing. This also constitutes an important phase of the elastic task.

Notes: Written in report form and handed to the "Record Assistant" prior to each quiz. The notes include *all* quantitative data, such as temperature readings, observed weights and volumes, calculations, etc.

Quiz: A written examination (thirty minutes) of at least five questions based on the "Procedure, Study Topics, Exercises," and the two specified "Required References."

Record: The following record is kept by the "Record Assistant" for each student. He also records all data reported by students and all "unknowns" issued.

1. Grade (%) on reported atomic weight of copper, based on a comparison with the correct value.
2. Grade (%) on reported atomic weight of copper based on the accuracy of the calculation from the reported specific heat.
3. Grade (%) on reported atomic weight of "unknown."
4. Grade (% × 2) on plotted data.
5. Grade (% × 4) on notes.
6. Grade (%) on exercises.
7. Grade (% × 5) on written quiz.
8. Grade (%) on laboratory application and technic.
9. Total (%) points on "Experiment III." (1600 possible.)
10. Average grade (%) for "Experiment III."

This experiment, including the written notes, the thirty-minute quiz, and the written exercises, required five laboratory periods of three hours each for its completion. The laboratory notes are compiled by the student during laboratory hours as he performs the experimental work, and a "Progress" check, obtained from an assistant at the end of each period, marks the daily progress. The exercises represent the only work required outside of laboratory hours. The required use of reference books in the laboratory prevents the more superficial student from skimming through the experiment. The rapid workers are encouraged to study the more advanced phases of the experiment in advanced texts.

Quantitative Aspects of "Experiment III"

One of the features of this method of instruction is the emphasis placed upon the quantitative technic. In Experiment III there are five quantitative values which the student determines experimentally.

(1) Specific heat of copper. (2) Atomic weight of copper (assuming its atomic heat to be 6.4). (3) Calculation of Dulong and Petit's constant from the specific heat of copper. (4) Specific heat of an "unknown" metal. (5) Atomic weight of the "unknown" metal.

An average of student values (determined experimentally for copper

by the use of Dulong and Petit's law) shows 72 to be the atomic weight of copper. This high value is caused by errors due to the simplicity of the apparatus and could have been offset by using a higher value for the Dulong and Petit constant. An error of this type cannot justly be considered a measure of the students' ability. It was found that 44.4% of Group *A* (36 students who had had no previous chemical experience) obtained values for the atomic weight of copper between 68 and 74 and that 66.0% of them obtained values between 64 and 74. Further, 35.7% of Group B (137 students who had had a previous secondary course in chemistry) obtained values between 68 and 74, and 61.3% obtained atomic weight values for copper between 64 and 74.

These data show that the results of Group A are slightly superior to those of Group B. Consequently we can conclude, at least, that this quantitative requirement did not work a hardship upon the students who had had no chemistry course in high school.

The average atomic weight values obtained by the entire class on a series of "unknown" samples show an average difference between two successive years of only 1.8%. Since these "unknowns" were actually alloys instead of pure metals, there was no possibility for the student to guess the correct value. This demonstrates that a satisfactory degree of accuracy is possible.

Seventy-nine per cent of the 1929-30 students in this chemistry course had had a previous course in secondary school chemistry. An average grade was computed from the average per cent grades on Experiment III for the students who had had no previous chemistry course in high school. A like grade was determined for the students who had had a previous high-school course. This average for the "non-high-school" group was 76.6%, while that of the latter group was 76.8%, showing a non-significant difference in favor of the group which had had a previous course in chemistry.

These grades are based upon eight items, including notes, preparation of graphs, solutions of problems, successful observance of quantitative data, and the writing of answers for the questions of a well-balanced and comprehensive quiz. Consequently, the writers feel that if the students of Group A (no high-school chemistry course) were deficient after the completion of the experiment, these grades would demonstrate this fact. Consequently, one is forced to conclude either that the tasks in Experiment III have enabled the students in Group A to overcome their handicap due to the lack of previous chemical experience, or that these tasks have not presented an opportunity for the students of Group B to take advantage of their previous secondary chemistry course. This will be discussed more fully later. At all events, the fact is obvious that the students with no previous chemistry have equalled the grades of the students who had had previous chemical experience.

Content of "Experiment IV"

The general content of Experiment IV is shown by the following outline:

Title: *Combining proportions by weight and the accurate determination of atomic weights.*

Object: An investigation of chemical weight relations and the experimental derivation of atomic weights.

Topics Covered: Conservation of mass. Law of definite proportions. Combining proportions. Atoms. Molecules. Atomic weights. Dulong and Petit's Law. Symbols. Formulas. Derivation of formulas. Use of beam balance. Quantitative synthesis of compounds. Per cent composition.

References: "Optional" and "Required."

Apparatus and Materials: A list.

Procedure: 1. *Combining proportions by weight.*

(*a*) The quantitative preparation of the sulfide of a known metal (copper). (*b*) Calculation of the percentage composition of the known sulfide. (*c*) The quantitative preparation of the sulfide of an unknown metal, "M." (*d*) Calculation of the percentage composition of the unknown sulfide. (*e*) The quantitative preparation of a known (copper) oxide by heating the metal in air. (*f*) The preparation of the oxide of an unknown metal "N" by means of nitric acid.

2. *Atomic weights.* (*a*) The calculation of the atomic weight of copper, sulfur, "M," and "N." (The value of the specific heat of each particular unknown is obtained from the Record Assistant.) (*b*) The calculation of the formula for each compound prepared.

Exercises: Ten problems.

Study Topics: A list of review topics.

Notes: In report form.

Quiz: Thirty minutes. Written.

Record: The following record is kept for "Experiment IV" by the Record Assistant. He also records all data reported by students and all "unknowns" issued to students.

1. Grade (%) based on per cent of copper in cuprous sulfide.
2. Grade (%) based on the per cent of "M" in the compound formed.
3. Grade (%) based on the per cent of copper found in copper oxide.
4. Grade (%) based on per cent of "N" in the compound formed.
5, 6, 7, 8. Grades (%) based, respectively, on reported atomic weights of Cu, S, "M" and "N."
9. Grade (% × 4) on notes.
10. Grade (%) on exercises.
11. Grade (% × 5) on thirty-minute written quiz.
12. Grade (%) on laboratory application and technic (obtained from the Floor Assistants).
13. Total number of per cent points. (Maximum of 2000 points.)
14. Average (%) grade on "Experiment IV."

The time required for the completion of this experiment was six laboratory periods of three hours each. During this time all *notes* were prepared, *required references* were studied, the *study topics* were reviewed and the quiz was written.

Quantitative Aspects of "Experiment IV"

In "Experiment IV" the student determines four quantitative values. (1) The per cent Cu in Cu_2S. (2) The per cent of metal in an unknown sulfide. (3) The per cent Cu in CuO. (4) The per cent metal in an unknown oxide.

From these data and the assumption that the atomic weight of oxygen is sixteen, a possible atomic weight of copper is calculated. This is checked against the value obtained in Experiment III from the determined specific heat value. In the same way a value for the atomic weight of sulfur is calculated. That for the two unknown metals is calculated from the student's data and checked against specific heat values which are obtained from the "Record Assistant." Unknown metals used for the quantitative preparation of oxides and sulfides are *Cu*, *Ni*, *Pb*, *Sn*, *Fe*, and *Al* (oxide only).

In the quantitative preparation of cuprous sulfide, the average value as determined by 125 students of Group B (those students having had previous chemistry courses) for the per cent of copper in their Cu_2S was 76.91, showing an error of -2.92%. The average value reported by 38 students of Group A (no previous chemistry) was 77.79% Cu, showing an error of -2.04%. It will be seen that in this instance the difference, although not significant, favors Group A. A similar conclusion is made obvious by a consideration of the results obtained in the quantitative preparation of cupric oxide. In this case, 34 Group A students reported with an average error of 2.70%, while 122 Group B students made an average error of 2.94%.

Calculation of an average grade from the "average per cent grade on "Experiment IV" for 31 students of Group A (no previous chemistry) who completed the experiment gave a value of 73.7%. A similar grade for the 118 students of Group B who completed this experiment was 72.5%.

It was thought possible that a distorted conclusion was possible because only students who *completed* "Experiment IV" were considered. Consequently similar grades were calculated for all students who started the experiment and who failed to complete it. The average grade for 36 students of Group A was 70.0%, while that for 125 students of Group B was 71.4%. This again is a non-significant difference. Further, since several of the withdrawals were due to extra-scholastic causes, this last comparison is considered to be less reliable than the one first listed.

In the early part of this paper it was suggested that the tasks of "Experiment III" were not designed to enable students to take advantage of previous chemical experience. This can hardly be said to be the case in "Experiment IV." The quantitative syntheses, the theoretical bases for the calculations, and the calculations themselves are difficult. A student with previous training in chemistry will be forced to utilize it as much as possible.

Conclusions

1. The authors have demonstrated that, in each item considered, the students who have taken previous secondary courses in chemistry have failed to show better technic or grades than the students who have had no previous chemical experience.

2. This has been made possible by the use of a previously described (*1*), (*2*) method of instruction which permits more efficient individual instruction.

3. An important phase of this method is the use of an elastic task which is suitable for students who have had varying previous chemical experience.

Summary

1. A brief discussion of two experiments occurring early in the semester is presented, showing their adaptability for use in the instruction of large general inorganic chemistry laboratory classes of students with varied previous chemical experience.

2. These large experiments represent an elastic task which taxes the ability of the better student and yet makes it possible for the weak but conscientious student to perform thoroughly an acceptable minimum requirement.

3. The average per cent grades, both for "Experiment III" and "Experiment IV" show no significant differences favoring those students who have had high-school courses in chemistry.

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Cosmic Rays Knock Electrons from Metals and Make Gas Conduct Electricity. The cosmic rays, that continually bombard the earth from outer space, have the power of knocking electrons out of the metal walls of a container holding gas. The electrons are knocked out of the metal with such a speed that they could travel for about 140 feet in ordinary air. But in such a container they ionize the gas, thus making it a conductor of electricity.

At a recent meeting of the American Physical Society in Cleveland, Dr. James W. Broxon, of the University of Colorado, thus reported on his researches to determine why a gas in a closed vessel is able to conduct electricity, a fact that has been known for some years. He also found that the conductivity of the gas increased with pressure but after it has reached 140 times the ordinary atmospheric pressure there is no further increase. His experiments were made with a lead chamber submerged in a tank of water.—*Science Service*

THE NEW AMERICAN METHOD OF TEACHING GERMAN*

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This article contains a description of the method in use for several years to teach the student of science to read German for comprehension. It is believed that in much less time it gives the student the ability to read the German text intelligently. Further, by this method much sooner than by the older ones, he becomes able to read understandingly without the medium of translation.

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A reading knowledge of German is necessary for the chemist. The method of teaching German to be described seems to be decidedly superior to the older methods in training the student of science. Hence we have felt it would be of interest to those responsible for the training of chemists.

It is called *new*—well, because it *is* new. It is called *American* because it is peculiarly well adapted, we think, to American conditions. *In Europe* the usual goal for a student of language is to acquire the ability *to speak* the foreign tongue. When a young man in Germany, for example, prepares himself for the hotel business, he generally finds it to his advantage to spend half a year or so in England and France. By this sojourn in the foreign country he does learn to speak the new language, no one would deny it, but his vocabulary, one will soon find, is extremely limited. But he has learned enough words for his purpose, namely to deal in a business-like way with the English and French patrons of the hotel in Germany where he is later employed.

Now *in America* the goal of the student essaying the learning of the foreign tongue, let us say German, is quite different from that of the average young man in Germany learning English. The student in America, for very practical reasons, has for his almost exclusive aim the acquisition of the *ability to read the printed page*, and he keeps this main goal in view constantly, whether the teacher likes it or not. He differs, furthermore, from the German in this, that he is intent upon and does succeed sooner or later in acquiring a great vocabulary, a passive one so far as oral speech is concerned, but an extremely active one for his own purpose, namely, that of reading for comprehension from the German printed text.

The practical reasons for this state of affairs in America are not far to seek. At the University of Arkansas, out of fifty students enrolled this first semester in advanced German, that is students taking second-, third-, and fourth-year German, thirty-three are majoring in some natural science; exactly sixty-six per cent of the total enrolment in advanced German classes. Now just what is it that this proportionately great number of science students wants with German? Are these science

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students perchance preparing to enter the German-speaking ministry of religion? Do they entertain notions of editing a German newspaper after graduation? Will many, or any, of them ever enter the United States diplomatic service in Germany, where a speaking knowledge of German will be absolutely essential? Why, of course, they will very probably do none of those things. These science students wish to be able to read German books and periodicals dealing with their chosen subjects in the natural sciences. Most of them would, frankly, not learn German at all, provided those scientific books and periodicals were by some miracle translated into English during their trip across the Atlantic.

A second reason for the stress that advanced students place upon the speedy acquisition of the ability to read German from the printed page is that these students seldom take more than two years of the language and in many instances they take only one. So, conditions being as they are, namely, that the students taking German are mainly students majoring in the natural sciences and interested in German chiefly as a tool, it is not fair or even practical to spend one-half or all of the time they devote to German on the acquisition of a mastery of sheer German grammar.

The originator of the method is Dr. George F. Lussky, Professor of German in the University of Minnesota, where this method has been used by him with excellent results, he tells us, for the last six years. He plans to publish his outline in book form sometime this year.

The objective of this method is, as has been indicated before, to teach the student to *read German for comprehension* and to do this in one year or less. The first textbook we use has been prepared by Dr. George Lussky in collaboration with Dr. Karl Ermisch of the University of Minnesota and contains sixty-six pages. It is divided into two parts, a reader of twenty-nine pages and a reference grammar of thirty-seven pages and is designed to extend over the first ten or twelve weeks of the student's beginning work in German. The reader is divided into ten lessons, each of which has a reading selection of about thirty lines, about eight exercises based on the reading selection, a set of twelve German questions also based on the text, and a very complete vocabulary of the words occurring in the specific lesson.

One big feature of this method is that the student begins to read German from the very first day, for this elementary book is printed in English characters—Roman type. The method takes into consideration that the scientific student who elects German will later read German books and scientific periodicals printed exclusively in Roman type. The idea is to proceed from the known to the unknown. The student's second book is "Geschichten und Maerchen" by Foster and Wooley (*1*), Part I of which is printed in Roman type but Parts II and III in Old English. Thus the student also becomes acquainted with German printed in the latter characters.

This second book will be used from about Thanksgiving until Easter. The third book, to be read from Easter to the end of the first year, is Schmidt's "Berühmte Deutsche Neuerer Zeit" (*2*) and is printed in Roman type exclusively. Even at that the Old English type should not offer tremendous difficulties later on, for the student surely is able to read the title of a newspaper like the **Arkansas Gazette** which appears in Old English.

Each lesson in the reader calls attention to certain portions of the reference grammar treated in that particular reading selection, and by the time the student has reached the end of the last lesson in the reader, he will at the same time have covered every paragraph in the grammar, so carefully have the reader and grammar been knit together. But this grammar material, upon which the whole reader is based, has been scaled down by the author to the very minimum. And well it might be, for consider: the whole purpose of this method is to teach the reading of German for comprehension. Hence the student can always assume *a correct German text* to begin with, which he must merely try to understand. The student does not have to be able to construct the German text himself; it is a given quantity which he must simply read and try to comprehend. So, according to this method, there are many points of grammar for the mastery of which he is never, during his first year of German at least, held responsible. Remember, this student is a science major who wishes merely to be able to read swiftly but intelligently from the pages of German scientific books and periodicals.

Let us try to show at this point how little grammar, after all, a student needs to know in order to absorb intelligently and completely the ideas presented to him in printed works through the medium of the foreign tongue. Let us take, for example, the German noun. Here the student must know that, whereas in English we have an abundance of ways to form our plurals, as house-houses, mouse-mice, ox-oxen, deer-deer, together with such seeming monstrosities as stratum-strata, phenomenon-phenomena, thesis-theses, the German language has only four ways: plurals ending in -e, some in -en, some in -er, and some with no ending at all. Now from the science student's point of view, having in every case—as he has a right to assume—a correct German text before him, it is vastly more important for him to be able to give the singular of any plural noun that he encounters in his reading than to be able to give the plural of the singular nouns found in the material before him. The reason is obvious: in any given case he must be able to reconstruct the singular from the plural in order to get at the correct meaning of the word and the part it plays in the thought of the sentence he is trying to ferret out. If the singular occurs, however, that is all he wants to know and needs to know for his purposes. Why, in all the world, should he be asked to give the plural of a word which actually occurs in the singular in the only place in which he is interested at the time?

What is meant is just this: what difference does it make to the student whether the plural of "Hand" is "Hand" or "Hande" or "Hände" or "Handen" or "Händer," just as long as he knows that the singular is "Hand," that it means the English word "hand," and that German plurals in general are formed by the addition of -e, -en, -er, or without any ending. He can safely leave the worries over all further details to the German scholar that writes the book and gets the royalties from it—whatever they may be in these days of reparations and world-wide business depression.

Let us next collar the pronoun and hold it up to the public gaze. Have any of you ever stopped to investigate how often—or rather how rarely—that evil demon of German grammar, the personal pronoun of the second person actually occurs in the reading matter of the poor bedevilled scientific student? Our answer is: practically never at all! When does the profound German author fall into a mood sufficiently confidential to address his reader with a chatty "you"—that author who according to most reports is not even on a familiar footing with his own wife and children? So why chase the bewildered science student across the bending ice with those savage grammatical blood hounds of "du," "ihr," and "Sie" written with a capital, baying at his heels? He will rarely, or perhaps never, meet with them again in all his born days!

The next bunch of grammatical gangsters that we have to round up and deliver over to a just punishment is that motley array of inflectional endings of the German adjective. More students—and teachers, too, perhaps—have been robbed of their patience by these base malefactors, without ever getting anything back for all their pains, than by any other of the numerous train of armed assassins let loose upon the class from the pages of the average approved German grammars. Let us dispose of this matter briefly thus: the student with the reading goal does not need to know the adjective endings at all, nor is he even conscious of these endings when he reads them. They represent merely so much superfluous print to him, much like the silent letters "ugh" in the English word "thought." And how many students, even after several years of German according to any method, are able to use the endings of the German adjective correctly and fluently?

In regard to the German verb, the same thing applies that was mentioned a moment ago about the personal pronoun of the second person: the student of science does not need to know the second person. It will occur so seldom in his reading that the grammar need refer to it only in a footnote. The only verb forms he must know intimately are the first and especially the third persons. And with that unruly roisterer of a second person properly confined in the guardhouse, the rest of the verb conjugation presents a simple, neat, dress parade of real attraction and charm.

And now, how about the German prepositions—those four long lists

showing which prepositions govern which case, all to be learned laboriously by heart upon pain of ex-communication from the serried ranks of the genuine thirsters after knowledge? How about the one list which gives the prepositions that are supposed to govern the dative if there is lack of motion implied and the accusative if there *is* motion implied and which, in reality, serves merely to drive the legalistic teacher into the mazes of "mental motion toward" and "mental abeyance of motion"? How about them, do you ask? Why, the science student simply laughs at all the lists. It is the learned author of the book or magazine article that must know his lists of prepositions, not the mere reader. What matters it to the student, in reading, whether a certain preposition happens to be followed by the dative, accusative, genitive, or even the nominative?

The New American Method of Teaching German stresses, of course, the acquisition of a large vocabulary and emphasizes the principles of word-building in German, word-formation, prefixes, suffixes, principal parts of verbs; it calls attention to troublesome words in translation, idiomatic constructions, idioms, synonymous expressions, words and phrases to be distinguished, and adds a useful list of helps on translation.

Another appropriate feature of this new method is the provision it makes for the answering of questions put in German and based upon the text, for it asks that the answers be given *either in German or English*. The student is reading merely for the understanding of the text. Furthermore, in order to accomplish this aim thoroughly, he is required to read extensively and to do everything within his power to add constantly to his vocabulary. But the new method also demands that *one paragraph* must be read intensively each day; this is done in order to make the student more and more conscious of the niceties of German diction and idiom. Further rules of German grammar are developed directly from the text as these points arise.

Still another requirement of this new method is the *reading aloud in German* of every selection before translation into English, for the ultimate aim of the whole method is to advance the student to a proficiency in reading directly from the German text without the medium of translation. A valuable aid toward this end is unquestionably to be found also in frequent exercises in German dictation.

If the science student returns for a second year of German, he is put through some good review book, as for instance, "German Grammar Review and Composition" by Dr. Baerg (*3*) of Wesleyan University, a work printed in Old English type, and later through a science work like "Technical and Scientific German" by Greenfield (*4*), printed in Roman type and containing articles of interest not only to the scientific student but also to the purely literary one. For, after all that has been said, one might readily hit upon the idea that if such a method for the rapid acquisition of a reading knowl-

edge of German without the waste of valuable time and energy on superfluous grammar material is good for the science student who will never employ his knowledge of German for actual conversational purposes, it surely will be just as good for the literary student who will use his knowledge of German *just as rarely* toward a speaking end.

So to sum up: *The New American Method of Teaching German* enables the student to learn to read the German text intelligently in one-fourth the time demanded of him by any of the older methods. In the second place, the student by this method, much sooner than by the older ones, gains the ability to read understandingly from the German text without the medium of translation. And just as Saul, the son of Kish, set out to seek his father's asses and found a kingdom, so also the intelligent student trained by this new method sets out to learn merely to read German from the printed page, and lo and behold, he very shortly gains also the ability to express himself in German, both orally and in writing, and can even readily understand German when spoken to him. And all of these things are added unto him with only one-fourth of the drudgery and needless memory work so rigidly insisted upon by the older methods of teaching German. Such certainly seem to be the results obtained from the use of this *New American Method of Teaching German.*

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(*2*) SCHMIDT, F. G. G., "Beruehmte Deutsche Neuerer Zeit," Alfred A. Knopf, New York City, **1929.**

(*3*) BAERG, GERHARD, "German Grammar with Composition," F. S. Crofts & Co., New York City, **1930.**

(*4*) GREENFIELD, E. V., "Technical and Scientific German," D. C. Heath & Co., New York and London, **1922.** Revised edition.

Aji-no-moto or Sodium Glutamate. An interesting condiment, which was devised and marketed by Japanese chemists several years ago, has come into wide usage throughout China and Japan, and is now making friends in this country. Chemically, the material is sodium glutamate. It is made from the gluten or protein part of wheat by acid hydrolysis, followed by bleaching, neutralization, and crystallization. It is thus of vegetable origin and does not violate the food prescriptions of any race or religion.

Aji-no-moto is a white powder, looking like bicarbonate of soda, of such character that it keeps well and may be dispensed from a salt shaker. It has a faint but definite odor of rather strong cheese. The taste, however, is that of the red juice from roast beef: salty, "meaty," and appetizing.

This condiment is the "making" of chop suey and other Chinese dishes. It goes especially well with spaghetti and other vegetarian dishes and makes them satisfying as well as filling. Its acquaintance is worth cultivating.—*Ind. Bull. of Arthur D. Little, Inc.*

A HIGH-SCHOOL COURSE IN PHOTOGRAPHY

K. M. Persing, Glenville High School, Cleveland, Ohio

The article is a brief summary of a two-year experiment in amateur photography as an elective science course. The course covers one semester of work and commands one semester credit toward graduation. An outline of the course of study being developed is included, and while it does not contain extensive detail it is complete enough to suggest the character of work done as well as serving as a nucleus for constructing other courses of study. The student works out a photographic project and assists in the photography of the school paper and yearbook. The course is a senior elective requiring two of the following subjects for admission: chemistry, physics, and art.

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To suggest another subject for an already overcrowded curriculum in the high school may seem like "adding the last straw," and yet with the attention of educators fixed on the practical aspect of education there seems to be a sufficient justification for doing so. The purpose of this paper is to point out some of the practical phases of such a course and also the interesting ones which make an appeal to the high-school student rather than to make a plea for an organized science elective. These observations will be based upon the results of a two-year experiment with amateur photography as an elective credit course in the senior high school.

It is a well-known fact that amateur photography has been an interesting plaything both in school and outside of school for a long time, in fact, since the cameras have been made more practical and less costly to operate. And it is also undoubtedly true, that many high schools have attempted to promote an interest in amateur photography through such activities as the camera club; the chemistry or science club; or as a part of the course in applied chemistry, and yet in view of these efforts we find that "the 8-hour finishing service" just around the corner at the drug store has grown by leaps and bounds. People are interested in making pictures of picnic groups, of athletic events, of the children at play, and various other activities, but find it too costly to have very many pictures finished, not realizing the small cost when finished at home. Too many people regard photography as a sort of magic performance. The attempts which have been made to promote amateur photography as an extra-curricular activity have been only partially successful due to the handicaps which are encountered in doing this kind of work. One of the most outstanding of these difficulties is the securing of suitable darkroom facilities in many school buildings, and of course this is the most important factor in conducting work in photography. Clubs have attempted to carry on this work quartered in small closets large enough only to accommodate one or two students; in other schools even such quarters are difficult to obtain. On the other hand, in some of the newer buildings fine darkroom laboratory space

is provided and unusual opportunities for the amateur photographer are opened up. In schools not fortunate enough to have these facilities, the cost of providing them is too great an investment to make for an extra-curricular activity. The writer feels that his experience as advisor to a camera club of approximately fifty members for a period of three years, enables him to appreciate some of the major difficulties which are likely to interfere with satisfactory work of this kind in a club program. It was the recognition of these difficulties, and a recognition of the practical nature of the work, that made possible the two-year experiment with photography as an elective science, a brief record of which is outlined in this paper. The organization, administration, and development of the work may be briefly described as follows.

The plan which has been followed at Glenville High School during the past two years in the course in amateur photography, provides for one semester work in the course, and allows a full semester credit toward graduation. It is an elective course in the twelfth year. The time allotment is the same as that in either the course in chemistry or physics, four periods for recitation and discussion and one ninety-minute period for laboratory practice per week. It has been found that many students will work from one to three periods in laboratory practice if they have the time available.

Who Are Admitted?

The problem of determining who should be admitted to the work in photography has been a difficult one and is by no means finally settled. The correct placing of a new course of study in the curriculum is always a more or less difficult problem and photography was no exception to the rule. There were two possibilities open in making a placement of this work; one was that of making the work a tenth-year science elective as a stimulus to other science courses; and the other was that of the twelfth year, because of the science work involved. Tentatively, the course has been made a twelfth-year elective, requiring at least two of the subjects—chemistry, physics, and art—as a prerequisite for admission to the work. The chief objection to placing the work in the tenth year is the fact that without the previous training in chemistry and physics the work would become almost entirely a mechanical procedure and the appreciation of the applied science and art would be lost.

The Course of Study

The selection of the content of the course of study was difficult and at present is considered as a tentative course of study. In view of the fact that there are very few books available on the subject of amateur photography it has been necessary to collect various pamphlets, booklets, and magazine articles dealing with the work and from these cull that which can

be used. The following books have been found very beneficial and are used as class and reference books by the students.

COLLINS, A. F., "The Amateur Photographer's Handbook," Thomas Y. Crowell Co., New York City, **1925.**

CHARLES, DAVID, "Commercial Photography," Sir Isaac Pitman Co., New York City, **1928.**

DAVIS, W. S., "Practical Amateur Photography," Little, Brown & Co., Boston, **1923.**

NEBLETTE, "Photography, Its Principles and Practice," D. Van Nostrand Co., New York City, **1930.**

WATKINS, ALFRED, "Photography, Its Principles and Practices," Constable & Co., London, **1920.**

MALLINCKRODT CHEMICAL WORKS, "Chemistry of Photography," Mallinckrodt Chemical Co., St. Louis, Mo., **1931.**

EASTMAN KODAK COMPANY, Rochester, N. Y.:

"Collodion"
"Commercial Photo Finishing"
"Elementary Photographic Chemistry"
"Good Pictures, How to Make" (used as text)
"The Fundamentals of Photography"
"Lantern Slides and How to Make and Color Them"
"About Lenses"
"Professional Enlarging and Equipment"
"X-Rays"

The following outline will serve to give the reader a bird's-eye view of the content of the course of study. It should be noted that extensive details have not been written into the outline since it is felt that more experimentation must be carried on before this can be done. It is the purpose of the writer to continue the work and determine possible minimum essentials, and the possible enrichment which might be expected of the more qualified workers.

An Outline

THE CAMERA

Kinds of Amateur Cameras
- The box type
- The folding type
- The reflecting type
- The movie camera

Kinds of Professional Cameras

Essential Parts of a Camera
- The box
- The lens
  - Kinds of lenses
    - Pinhole
    - Meniscus
    - Rapid Rectilinear
    - Anastigmatic
  - Properties of lenses
    - Focal length
    - Depth of focus
    - Speed

The Shutters
- Apertures of Diaphragm
  - Function
  - System of naming
- Kinds of Shutters
  - Operation of—
  - Function of—
    - Rotary type
    - Between the lens type
    - Focal plane type

LIGHT AND ITS RELATION TO PHOTOGRAPHY

Nature of Light
Color Sensitive Materials
- Photographic Plates and Films
  - Orthochromatic
  - Panchromatic
- Paper
  - Kinds of—
    - Sun printing
    - Developing
    - Bromide
    - Blue print

Kinds of Light
- Natural or Daylight
  - Photographic value
- Artificial
  - Gas
  - Mercury vapor
  - Incandescent
  - Arc
  - Flash
- Advantages and disadvantages of each type of light

Light Filters
- Theory of—
- Value of—
- Kinds of filters and their use

MAKING THE EXPOSURES

Factors Which Influence the Taking of Pictures
- Seasonal, time of day, condition of weather
- Light
- Composition of picture
- Lens
- Time of exposure

Kind of Pictures
- Landscape
- Marine
- Snow Scenes
- Groups, outdoor
- Individuals, characteristic pose
- Buildings
- Athletic events
- Home portraiture
- Flashlight
- Silhouette
- Animal life

MAKING NEGATIVES

Types of Development
- Tray
  - Advantages
  - Disadvantages
- Tank
  - Advantages
  - Disadvantages

Kinds of Developer
- Chemistry of the developing agents
- Advantages of the several kinds of developers

Factors Influencing Negative Making
- Exposure
  - Correct
  - Underexposure
  - Overexposure
- Period of Development
  - Correct development
  - Under development
  - Over development
- Fixing and Hardening
  - Chemistry of the fixing and hardening baths
  - Time for fixing
- Washing and Drying
  - Need for thorough washing
  - Danger of spotting

Theory of Development and Fixing
- Thorough discussion of the chemistry of these processes

MAKING THE PRINTS

Kinds of Prints
- Sun Prints
- Developing papers
- Bromide prints
- Blue prints

Factors Influencing Quality of Prints
- Character of Negative
  - Contrasty
  - Flat
  - Thin
  - Dense
- Correct Paper
  - Degree of contrast suited to negative
  - Grade and surface
  - Weight of paper
- Kind of prints
  - Contact
  - Projection

Exposure
- Results of over- and under-exposure
- Correct timing of exposure essential

Development
- Condition of Developer
  - Temperature
  - Concentration
  - Kind of—
  - Old developers produce poor prints
- Incomplete Development
  - Due to overexposure
- Forced Development
  - Underexposure

Fixing and Washing
- Theory of development and fixing from the standpoint of the chemistry involved

Toning of Prints
- Sun prints
- Sepia and colored prints

Poor Prints, the Causes and Remedy

PREPARATION OF SOLUTIONS

(The student mixes all solutions used from formulas furnished in the manual or by the instructor)

Developers
- Film
- Paper

Chemicals Used and Their Function in the Formula

Some Correct Formulas

Short Stop
- Its purpose

Fixing Bath
- Correct formulas and correct concentration of hypo

Hardening Solution
- Purpose
- Formulas

Intensifiers

Reducers

Toning Solutions

PORTRAITS

Posing

Lighting

Retouching

Printing

Mounting

COMMERCIAL PHOTOGRAPHY

Field of Commercial Photography
- Advantages
- Disadvantages

Photostat

Blue Print

Applications
- In Advertising

ART IN PHOTOGRAPHY
MOTION PICTURE

Cameras
- Construction and Operation
  - Professional type
  - Amateur types

Film
- Kinds
  - Nitrate, inflammable
  - Acetate, non-inflammable
  - Orthochromatic
  - Panchromatic
  - Autochrome

Exposures
- Theory of motion pictures

Development and Printing
- Negatives
- Positives

LANTERN SLIDES

The Slide
- What is it?
- Uses

Exposure
- Contact printing
- Projecture printing

Development and Fixing

Intensification

Reduction

Mounting, Toning, Tinting, Titles

ENLARGEMENTS

Projector or Enlarger
- Simple type, fixed focus type
- Camera as a projector type
- Auto focus type

Printing
- Kinds of paper
  - Bromide
  - Chloride
- Exposure
  - Local control, diffusion, etc.

Development, fixing, mounting, safelight, developer, etc.

X-RAY

Theory of X-Ray Photography
Cameras
Exposures
Development and Fixing
Use of—

COLOR WORK

Three-Color Process
Theory of—
Autochrome Work
Painting, Tinting, Toning
Halftones for Color Printing

Laboratory Practice

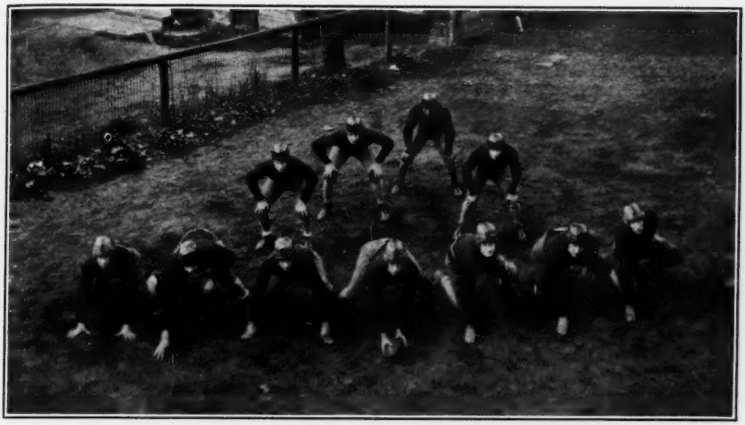
The laboratory phase of the photographic work is one of the most important parts of the course since it is here that the student acquires a technic for doing the finishing work. It is very important therefore that the greatest economy be practiced in the use of the laboratory period, and to accomplish this it has been found that demonstration of the various types of work to the class group before sending them to the laboratory has been worthwhile. Each student spends from one to three ninety-minute periods in practice work depending upon the amount of time available, and practices the several types of work involved in making acceptable pictures. The equipment will be discussed briefly under the laboratory equipment. A considerable amount of time is devoted to the construction of projects outside of the school period. These projects include the construction of apparatus needed in equipping an amateur photographic laboratory.

Projects

In addition to the regularly assigned laboratory practice work required by the several topics of the course of study, each student is encouraged to plan and complete a project or special piece of work. A selected list of projects is prepared and given to the members of the class, and this list consists of two types of work; one is a picture project; and the other is a construction type of apparatus or equipment. The student may select his project from the suggested list or he may select another project subject to the approval of the instructor. The following list of projects has been used for students' guidance in making a selection of a project.

A. PICTURE PROJECTS

1. Architecture of Cleveland churches
2. Architecture of public buildings
3. Architecture of school buildings in Greater Cleveland
4. Types of municipal buildings in Greater Cleveland
5. Scenes in Cleveland metropolitan parks
6. Winter scenes
7. New and old types of gasoline service stations
8. Views in and about Cleveland airport
9. Some types of airplanes
10. Wayside lunch stands and barbecues



FOOTBALL TEAM FOR YEARBOOK

11. Character pictures of the faculty
12. Character pictures of high-school students
13. Pictures of high-school activities, athletics, art, class, etc.
14. High-school athletes
15. Interior pictures of home and school
16. Flashlight pictures
17. Home projects
18. Picnic scenes, hikes, tennis, sports
19. Silhouettes
20. Enlargements

B. CONSTRUCTION PROJECTS

1. Construct a photographic printing box
2. Make safe lamps for darkroom
3. Build an enlarging camera
   a. Fixed focus
   b. Focusing type, using camera
4. Construct bank of lamps for interior lighting
5. Prepare backgrounds, decorated
6. Construct screens and reflectors
7. Build a micro-photographic camera

In planning any of the above projects the student has frequent conferences with the instructor in order to save both time and money. The average student will be able to plan and furnish his own laboratory with a minimum of cost. The picture projects as well as the other projects are entered in the semester exhibit. The construction projects have proved both interesting and profitable to the students. An example will serve to illustrate this point. One boy purchased an old-type camera for seventy-five cents, and converted it into a very satisfactory micro-photographic

EXAMPLE OF INTERIOR PHOTOGRAPHY BY STUDENTS

SPORTS LEAGUE

EXAMPLE OF GROUP PHOTOGRAPHY

camera with which he made a series of lantern slides from the microscopic slides for the use of the biology classes. The instructors selected subjects which would be useful in their work. Several very efficient enlarging cameras were also constructed. These either used the kodak as a projector or were of the fixed focus type.

Exhibits

The semester exhibit of the photographic work of each class has been established as a definite phase of the work and it is expected that each student enrolled in the course will have an entry. This part of the work is considered an important feature of the course since it makes possible the inspection of the work by the entire school. In the event that members of the class have prepared lantern slides it is interesting to have them give an illustrated lecture to other science groups or to small units as may be arranged.

Equipment

In general the student uses his own camera. It has been found that better pictures are produced if the students know the possibilities of a particular camera. Later in the course opportunities are provided for using several types of cameras; students may exchange if they wish to do so. At present the school equipment includes the following cameras:

STUDENT PHOTOMICROGRAPH OF BASSWOOD STEM

1—8 × 10 Agfa with Gundlach f. 6.3 lens

1—$3\frac{1}{4} \times 4\frac{1}{4}$ Seneca equipped with Wollensack Velogstigmatic f. 6.3 lens

1—$2\frac{1}{2} \times 4\frac{1}{4}$ Single Lens Camera

1—$2\frac{1}{4} \times 3\frac{1}{4}$ Ansco f. 6.3 lens

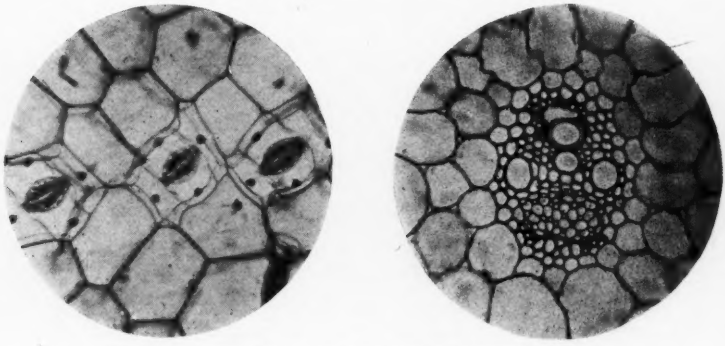
Other types are planned as funds become available.

The students' assortment of cameras included all types and some interesting results have been obtained by an exchange of cameras among members of the class.

Supplies

The problem of supplies may best be considered under two main headings: (*a*) *Chemicals;* and (*b*) *Supplies.*

Chemicals: It has been found economical to purchase the chemicals needed, in large quantities rather than smaller amounts as required for immediate needs. As far as possible the chemicals are requisitioned in the same manner as the regular supplies for the chemistry department. A few special materials must be purchased by the department. The various solutions such as developers, reducers, intensifiers, toning solutions, fixing baths, etc., are mixed as stock solutions by committees of students and dispensed to individuals as needed for their work. The other plan of each student mixing his own stock solution was tried but did not seem as practi-



STUDENT PHOTOMICROGRAPHS OF CROSS-SECTIONS OF STEMS

cal. The fixing bath may be contained in a large tank used by the entire group, or each section may be provided with a tank of fixing bath.

Supplies: These include films, printing papers, mounts, and other items used by the group. The individual students must assume the expense of these items. For convenience a stock is kept by the instructor and sold to students.

The School Project in Photography

The investment by the school in the large camera has made possible the development of the project from a practical standpoint. Since the purchase of the camera the class in photography in conjunction with the regular picture committee of the senior class planned the club and extra-curricular activity pictures for the *Annual*. While a considerable amount of the work must be done by the instructor there is provided excellent opportunities for the class members to study grouping, posing, lighting, color effects, and the various other factors that must be considered in group photography. It has also afforded opportunity to study the situation toward obtaining new views of the building and vicinity for use in the yearbook.

From a purely financial consideration it may be added that the saving on the group picture work for the yearbook, plus the revenue from sale of pictures to the student body, has more than paid off the initial investment.

Summary

The outline of the experiment in amateur photography is a summary in itself and no conclusions seem necessary, except to point out that the interest in and results obtained seem significant. The work provides opportunities to demonstrate science and art in application. Opportunity is afforded the student to get a first-hand glimpse into the technic of commercial photography which has revolutionized our advertising programs. In addition, it enables the student to appreciate the recreational value of the camera.

German Chemical Industry. A recent special report on the German chemical industry contains 500 pages and includes contributions from nearly forty general managers and other experts. Comprised within the industry are 3000 plants with 320,000 employees. It is handicapped by the foreign competition developed since the war and by the dominating power of the I. G. Farbenindustrie, which is so active in almost all fields of chemistry that independent initiative is throttled. Meanwhile, about 13 per cent of the world's production of chemicals is now manufactured in countries which had no chemical manufacture of importance in 1913. At that date the world production was about $2,500,000,000 in value. For 1927 it has been estimated at $5,250,000,000.

It is significant that from another source in Germany there has been issued a demand for more research.—*Ind. Bull. of Arthur D. Little, Inc.*

SEGREGATION OF HIGH-SCHOOL CHEMISTRY PUPILS*

DRULEY PARKER, SHORTRIDGE HIGH SCHOOL, INDIANAPOLIS, INDIANA

A plan is proposed for the segregation of pupils in high-school chemistry on the basis of previous achievement, native intelligence, initiative, originality, and arithmetical ability. The article contains a description of the three courses offered at Shortridge High School to the various groups.

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Shortridge is a classical high school of the college preparatory type. Located on the north side of the city, the student body is composed of three thousand children from the homes of business and professional people. The teaching force is noted for the small teacher turnover.

Two years of a laboratory science are required for graduation. The sciences offered are chemistry, physics, physiography, physiology, geology, astronomy, botany, and zoölogy. The chemistry department has the the largest enrolment of any single science, having eighteen classes in chemistry, enrolling four hundred thirty-two pupils. Two semesters of chemistry are offered for juniors and seniors, and a third semester (elementary quantitative analysis) is given when the capacity of the department permits.

During the first semester there is no segregation of students, the course being of such an elementary nature that only about two per cent of the students fail. At the end of the first semester the students have studied oxidation and oxygen, the composition of the air, carbon dioxide, water and solution, and hydrogen. The approach to the subject has been entirely from the laboratory side, the textbook being used only after a unit of work has been thoroughly studied in the laboratory and in classroom discussion. The atomic theory, Avogadro, formulas, and equations have not been introduced. Naturally, the second semester is much more difficult for those students who are poorly prepared arithmetically.

Several years ago segregation of the most promising students into a special group was started and this group was taught by the head of the department. Last year, due to the growth in enrolment, two of these special classes were organized for the spring semester and the practice has been continued this year. The basis of this selection is the performance in the work of the first semester. The intelligence quotient for each student is also on file. Some of the desirable qualities that are given weight in selecting the personnel of these classes are native intelligence, initiative, originality, and arithmetical ability.

This group of students is given a course approaching a college course in detail, thoroughness, and standards of attainment. The theoretical phases of the subject are developed in detail, such topics as the following being

* Presented before the Division of Chemical Education of the A. C. S. at Indianapolis, Indiana, April 1, 1931.

studied: derivation of atomic and molecular weights, atomic structure with some of the physical basis for the same, ionization as a logical sequence of subatomic structure, oxidation and reduction from the electronic standpoint, chemical equilibrium, and hydrolysis.

As soon as the fundamentals are covered, which requires about twelve weeks, the class spends the remainder of the semester on individual projects. As a general rule each student has time to carry two projects to completion. This semester it is planned to bend this project work, with one class, into inorganic preparations. This is merely an experimental idea of the teacher. A discussion of the project work is a fascinating subject in itself.

At the beginning of the spring semester of 1931 further segregation of the remaining second-semester students was made into two divisions. Students who had not been particularly happy or successful in the work of the first semester were placed in separate classes. These pupils are characterized by only a mild interest in the subject, a lack of curiosity, and an apparent inability to follow a line of reasoning or to do any real thinking. At the beginning of the semester a class project was carried out to arouse the lagging interest of these pupils. Some old sterling silver was obtained from a wholesale jeweler and the class prepared silver nitrate from this and made an assay of the alloy in the process. This gave an opportunity to teach oxidation by means of nitric acid, from the descriptive standpoint. The displacement series was also taught.

This project was followed by another where the students reclaimed the gold from old watch cases loaned by a generous jeweler. These projects aroused much interest, some genuine and some superficial. No attempt was made to develop the derivation of atomic and molecular weights but the writing of formulas from valences and the writing of simple equations was taught. Simple stoichiometry was also included. It is planned to have these students follow the textbook rather closely and to receive considerable drill. This is our first attempt at something of this sort and we are regarding the project with much interest.

After the two classes of superior students and the two classes of inferior students are segregated the remainder of the students are divided into eight classes. These are known as "regular" classes. Their course consists of the derivation of atomic and molecular weights, subatomic structure, acids, bases, salts, neutralization, ionization, electrolysis, equilibrium, and hydrolysis. Practically the same theory is taught in this class as in the superior group but much of the detail is omitted. After the theoretical phases have been developed, the remainder of the semester is spent in a study of the alkali metals and their more important compounds and those of the alkaline earths.

It is hoped that by this method of segregation we are doing something to meet the problem of individual differences.

CHEMICAL ENGINEERING AS A PROFESSION*

JOHN C. OLSEN, THE POLYTECHNIC INSTITUTE, BROOKLYN, NEW YORK

The field of the chemical engineer, which is distinct from that of the chemist and the mechanical engineer, is first discussed. Twenty-five to thirty years ago this distinction was not recognized. There has been such a great advance in the special knowledge and literature of chemistry and chemical engineering and also in mechanical engineering that it is no longer possible for a single man to combine these two fields.

The work of the chemical engineer is to develop commercial processes, design the equipment, superintend the installation and the operation of industries manufacturing chemical products. In order to do the work in this field the profession of chemical engineering has been developed. The engineering schools and universities which have offered specialized courses in this branch of engineering have today an enrolment of about 5000 chemical engineering students with an aggregate annual graduating class of not far from 1000.

The American Institute of Chemical Engineers was organized twenty-three years ago to foster the public and professional relations of the chemical engineer and encourage the publication of chemical engineering literature. This organization now numbers nearly a thousand members and is growing rapidly. The literature of chemical engineering has been developed at an ever-increasing rate during this period. The well-educated chemical engineer who understands the fundamental operations in this branch of engineering is now able to take positions of responsibility in any of the numerous chemical industries. This arises from the fact that chemical engineering processes have been analyzed and found to consist of a number of typical and fundamental unit operations which are employed in their proper sequence in all chemical industries.

The magnitude of the chemical engineering industries is indicated by the fact that the total output in 1929 had a value of eleven billion dollars representing approximately one-fifth of all manufacturing industries in the U. S. The petroleum industry is the largest single employer of chemical engineers, having taken 15 per cent of the chemical engineering graduates in 1929.

The chemical engineer is concerned with technical research and production and economic aspects of the chemical industries. Many of the higher executives in these industries are technically educated chemical engineers.

The compensation received by chemical engineers is comparable with that received by engineers in other fields doing work of corresponding importance or occupying positions of equal responsibility. The initial annual salary of the young man graduating from the usual four-year course will be from $1500 to $1800. The graduate with a master's degree will receive a somewhat larger compensation ranging from $2000 to $2400, while the man having a doctor's degree will receive from $2400 to $3000. In from five to seven years this compensation is usually doubled.

* Delivered before the students' course in Elementary Chemical Engineering held at the 13th Exposition of Chemical Industries, New York City, May, 1931.

Many problems still await solution. The loss in the petroleum industry from corrosion alone is $125,000,000 annually. A billion gallons of gasoline is lost every year by evaporation. An excellent illustration of the important service of the chemical engineer is found in the wood distillation industry which was seriously threatened by the production and marketing of synthetic methanol and acetic acid. By applying modern chemical engineering methods the yield and purity of the products of the wood distillation industry were so improved and the methods so modernized that this industry was saved. Many other technical processes needing improvement and modernization await the service of the chemical engineer. Only those industries whose managements realize this fact and avail themselves of the services of the chemical engineer will long survive modern competitive business conditions.

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Before discussing the professional aspects of my subject it will be necessary to define the field of the chemical engineer. As the name implies, only those operations which are based upon *chemical* reactions would be included in the work of the chemical engineer. By no means can all such operations be classified as chemical engineering. The man who operates the chemical engine of a fire department cannot be designated a chemical engineer even though the fire-extinguishing liquid which he uses results from a chemical reaction. The reason for this is that this fireman does not need to know even the most elementary chemical principles in order to be an efficient fireman.

On the other hand, the man who invented this method of extinguishing a fire and designed the machine which utilizes chemical reactions for this purpose might properly be classified as a chemical engineer. Such a man must understand not only fundamental *chemical* principles but also the *mechanical* principles involved in the design of the apparatus in which the chemical reaction will take place. In this case it is absolutely essential that the chemical reaction shall be under such control that it may start *instantly*, progress at a *predetermined rate*, producing a *definite* product, while it is equally essential that the reaction shall *not* take place until the instant when the apparatus is needed to extinguish a fire. Even a few seconds' delay at this critical moment may mean the loss of a great deal of valuable property. It is the combination of just this kind of rigid control of chemical reactions together with mechanical skill which constitutes the work of the chemical engineer.

It should of course not be overlooked that the *chemist* first worked out the reaction between the bicarbonate of soda and acid, or aluminum sulfate, which is utilized in the acid and soda, or foam extinguisher. The design of the apparatus which makes use of these reactions for extinguishing a fire is the work of a chemical engineer.

Twenty-five or thirty years ago it was considered that the man who was chemically trained and had native mechanical ability, or the mechanically trained man who had an elementary knowledge of chemistry could satisfactorily do the work of the chemical engineer. At that time the then president of the Massachusetts Institute of Technology expressed the opinion that a chemical engineer was a mechanical engineer who had an acquaintance with chemistry. Since that time the science of chemistry, particularly theoretical and physical chemistry, has made such enormous strides that it is beginning to become questionable whether the graduate of a four-year course in chemistry from one of our best educational institutions has acquired a sufficient grasp of the fundamentals of chemistry to be able to read intelligently modern chemical literature. The principles covering the control on an industrial scale of even very simple chemical reactions have been very highly developed. The industrial research chemist has very often spent three or more years after his college course in study and investigation in one of our universities before he is competent to devise or improve a modern industrial chemical process.

Similarly very great advances have been made in the production of power and the design of mechanical equipment which is the special field of the mechanical engineer.

It has therefore been found necessary to educate and develop a type of engineer who has specialized in the design of apparatus and the control of operations which are fundamentally chemical. This field of the chemical engineer has been found sufficiently well defined and specialized to constitute the basis for a new branch of engineering. The engineering schools and universities have offered specialized courses for this branch of engineering so that today there are about 5000 chemical engineering students in our American institutions with an aggregate annual graduating class of nearly 1000.

Twenty-three years ago the American Institute of Chemical Engineers was organized as a professional society to foster the public and professional relations of the chemical engineer and encourage the publication of chemical engineering literature. This organization now numbers nearly 1000 members and is growing rapidly. Chemical engineering literature has also developed at an ever-increasing rate during this period. There are now available some thirty volumes of the *Transactions of the American Institute of Chemical Engineers* as well as seven most excellent volumes of the *British Institution of Chemical Engineers*, a large number of most excellent monographs and textbooks, as well as several periodicals such as *Chemical & Metallurgical Engineering* and *Industrial & Engineering Chemistry* of the American Chemical Society, devoted almost exclusively to the current literature of chemical engineering. The current literature of chemistry and chemical engineering has become so voluminous that many members of

the American Chemical Society interested in pure chemistry can find time to read only the periodicals in this field, while other members interested in chemical engineering read only the industrial journal. Specialization is rapidly becoming inevitable on account of the limitations of time alone.

In spite of this situation, the special field of chemical engineering is by no means generally recognized. The organized body of chemists has not conceded that the chemical engineer is anything more than a special kind of chemist, while the mechanical engineer often contends that he has ample knowledge of chemistry to design and operate chemical engineering equipment. With the rapidly increasing specialized knowledge of both chemistry and engineering as well as the arrival of a large body of younger well-trained chemical engineers both of these points of view will gradually disappear.

The recognition of chemical engineering as a separate branch of engineering has been greatly accelerated by the recognition that every chemical-engineering process consists of a number of well-defined unit operations which in their proper sequence constitute a complete process. The man who has a proper understanding of these unit operations may successfully serve industries whose fundamental operations are very different chemically. This is well illustrated by the records of a group of ten chemical engineers reported by H. C. Parmelee (*1*).

Employment Records of Ten Typical Chemical Engineers in Industry

	Successive Positions Held	*Industry in Which Employed*
1	Ass't Supt.	Water Gas
	Chemist	Paint and Varnish
	Superintendent	Dyeworks
	Works Manager	Electrochemicals
	Superintendent	Fine Chemicals
2	Research Chemist	By-product Coke
	Superintendent	Metal Refining
	Superintendent	Lithopone Mfg.
	Ass't Supt.	High Explosives
3	College Professor	Organic Chemistry
	Chemical Engineer	Indigo Manufacture
	Superintendent	Coal-Tar Chemicals
	Vice President	Dye Manufacture
4	Chemical Engineer	Leather Tanning
	Engineer of Design	Equipment Mfg.
	Chemical Engineer	Fine Chemicals
	Chemical Engineer	Asphalt
	Plant Engineer	Fine Chemicals
	Consulting Engineer	Chem. Engineering
5	Foreman	Electrochemicals
	Superintendent	Coal-Tar Products

	Successive Positions Held	*Industry in Which Employed*
	Ass't Supt.	Synthetic Phenol
	Superintendent	Explosives
	Plant Engineer	Fine Chemicals
6	Chemist	Electrochemicals
	Foreman	Iron and Steel
	Superintendent	Sulfuric Acid
	Superintendent	Explosives
	Superintendent	Caustic Soda
	Plant Manager	Pyroxylin Lacquers
7	Chemical Engineer	Matches
	Chemical Engineer	Dyeworks
	Superintendent	Sulfur Chloride
	Plant Engineer	Electrochemicals
	Chemical Engineer	Rubber
8	Research Chemist	By-product Coke
	Chemical Engineer	Pulp and Paper
	Chemical Engineer	Fine Chemicals
	Superintendent	Dyeworks
	Construction Engr.	Poison Gas Plant
	Plant Engineer	Fine Chemicals
9	Wood Paving Inspector	New England City
	Development Engr.	Coal-Tar Products
	Chemical Engineer	Pharmaceuticals
	President	Consulting Engineers
	Superintendent	Dyeworks
10	Operator	Coated Paper
	Chemist	Iron and Steel
	Sales Engineer	Equipment Mfg.
	Superintendent	Beet Sugar Plant

It will be noted from this table that the man doing chemical engineering work is not always designated as a chemical engineer but that he often holds positions such as superintendent, plant manager, vice president, etc. The industries which he serves cover the entire range of chemical industries. Only in the case of number three are the industries in the same general division of chemical industries, namely, dye manufacture.

The well-trained chemical engineer is evidently no longer limited to a single basic chemical industry as was often true in the past.

The unit operations as commonly recognized are as follows:

Evaporation	Drying
Distillation	Absorption and Adsorption
Mixing and Agitation	Crushing and Grinding
Heat Transfer	Flow of Fluids
Materials Handling	Crystallization
Filtration	Classifying and Screening

A study of any one of the following very diversified chemical industries will show that the processes employed are merely aggregates in proper sequence of the unit operations listed:

Heavy Chemicals	Fine Chemicals
Electrochemicals	Dyes and Coal-Tar Products
Explosives	Coal Processing
Petroleum Refining	Wood Distillation
Sugar Refining	Pulp and Paper
Cement and Lime	Soap
Fertilizer	Paint and Varnish
Rubber	Glass
Gas Manufacture	Vegetable Oils
Ceramics	Textiles and Rayon
Leather	

Market Rating Figures for the Process Industries

INDUSTRY	Number of Establishments	Number of Wage Earners	Value of Products	Cost of Materials, Supplies	Cost of Fuel and Power	Value Added by Manufacture	Installed Horsepower
Chemicals and Chem. Prep.	2,372	119,684	$884,976,741	$366,514,044	$55,575,986	$462,886,711	784,017
Ceramics, Brick and Clay	2,218	138,687	436,103,772	74,592,819	60,787,765	300,723,188	594,746
Coke	171	21,082	382,012,617	27,517,965	259,210,736	95,283,916	451,874
Drugs, Medicines and Cosmetics	2,385	36,331	559,002,970	180,818,345	2,770,963	375,413,662	65,094
Explosives and Fireworks	136	7,367	78,374,607	37,749,971	1,767,277	38,857,359	38,539
Fertilizers	621	18,612	190,384,890	135,368,365	2,774,560	52,241,965	156,274
Glass	269	65,825	282,394,330	79,441,368	30,470,096	172,482,866	318,298
Gelatin, Glue and Adhesives	141	3,728	39,141,210	21,416,371	2,076,374	15,648,465	26,962
Leather, tanned	494	52,924	494,255,838	324,321,487	7,663,249	162,271,102	220,530
Lime and Cement	421	47,225	335,152,751	69,185,452	68,096,040	197,871,259	1,153,585
Gas Manufactured	828	48,497	516,705,170	87,249,955	124,535,568	304,919,647	496,014
Oils and Greases, Animal and Veg.	1,073	30,382	563,848,596	427,546,715	10,934,351	125,367,530	357,467
Paints and Varnishes	1,006	28,061	519,009,842	300,599,001	7,125,369	211,285,472	163,187
Paper and Pulp	929	123,360	1,138,089,666	647,167,490	76,943,473	413,978,703	2,642,806
Petroleum Refining	354	71,234	2,142,648,503	1,649,288,320	103,708,723	389,651,460	552,651
Rayon	19	26,341	109,888,336	22,743,855	3,003,937	84,140,544	122,406
Rubber Goods	516	141,997	1,225,077,114	639,934,922	20,435,287	564,706,905	790,622
Soap	597	15,835	328,294,401	183,029,112	4,434,653	140,830,636	70,510
Sugar	153	22,369	710,381,336	623,244,405	13,197,054	73,939,877	274,707
Other Process Industries	1,876	80,036	792,499,557	401,733,106	24,477,932	366,286,519	720,896
Total	16,579	1,099,577	$11,728,242,247	$6,299,463,068	$879,989,393	$4,548,789,786	10,002,207

Source: U.S. Census of Manufactures, 1927

Chemical & Metallurgical Engineering Market Research Dept.

TABLE I

For instance, in sugar refining the raw sugar is dissolved in water and the impurities are precipitated out by means of lime and phosphoric acid. The precipitate is removed by means of a suitable filter press. The sirup is decolorized by adsorption with bone black. The clarified sirup is then evaporated in vacuo until the sugar crystallizes out. The sugar is separated from the remaining sirup by means of centrifugal machines and

washed. After drying the sugar is ready for the market. In this industry the following unit operations in the following order have been employed: filtration, adsorption, evaporation, crystallization, drying. Heat transfer, materials of handling, and flow of fluids have also been applied in carrying out these operations.

In a similar manner the other processes listed may be shown to be aggregates of unit operations in proper sequence.

The magnitude of these industries is indicated by the fact that their total output in 1929 was $11,000,000,000, representing approximately a fifth of all manufacturing industry in this country. While the technical

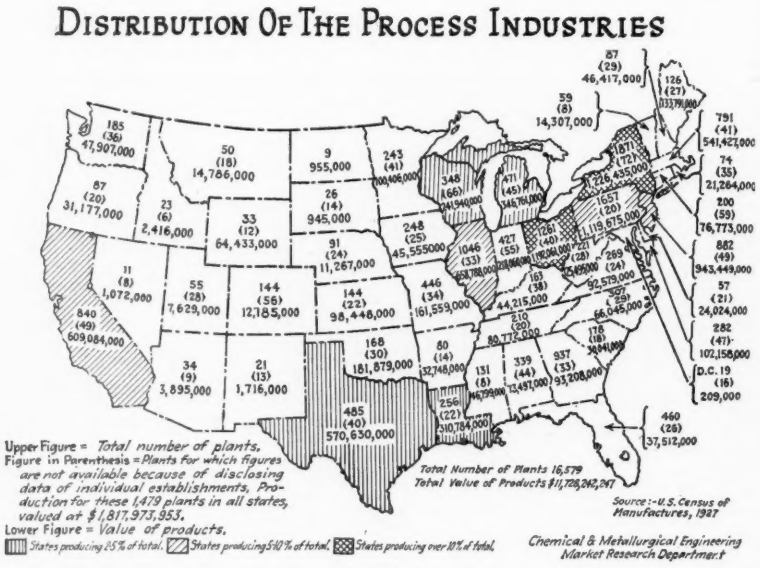

DISTRIBUTION OF THE PROCESS INDUSTRIES
Upper Figure = Total number of plants,
Figure in Parenthesis = Plants for which figures are not available because of disclosing data of individual establishments, Production for these 1,479 plants in all states, valued at $1,817,973,953.
Lower Figure = Value of products.
States producing 25% of total.
States producing 5 to 10% of total.
States producing over 10% of total.
Total Number of Plants 16,579
Total Value of Products $11,728,242,247
Source:-U.S. Census of Manufactures, 1927
Chemical & Metallurgical Engineering Market Research Department

TABLE II

control of these industries must be in the hands of the chemical engineer because the fundamental reactions are chemical, other technical men must be employed and coöperate in their special fields such as the chemist, mechanical, and electrical engineer, etc.

It will be noted from Table I that there are a total of 16,579 chemical establishments in the United States employing a total of 1,099,577 wage earners. It is rather surprising to note that the three industries having an output of more than a million dollars worth of products are in the order of size, petroleum refining, rubber goods, and paper and pulp. While the cost of materials is $6,299,463,068, the value added by manufacture is

$4,548,789,786. This increase in value is a product of the work of the chemist and chemical engineer.

It will be noted from Table II that the greatest concentration of chemical industries is found in New York State and Ohio, with Pennsylvania, New Jersey, and Illinois coming next, followed by Michigan, Texas, Louisiana, and California. The remaining unmarked states on the map have relatively few chemical industries.

Table III shows very clearly that the most diversified chemical industries use the same standard equipment. It is this uniformity of processes carried

The Process Industries Market for Equipment

Process Industries	Material Handling: Solids	Material Handling: Liquids	Material Handling: Gases	Disintegration	Chemical Reaction	Agitation & Mixing	Mechanical Separation: Solid from Solid	Mechanical Separation: Solid from Liquid	Mechanical Separation: Liquid from Liquid	Mechanical Separation: Solid & Liquid from Gases	Evaporation, Distillation and Crystallization	Heat Transfer	Drying	Power Transmission	Refrigeration	Process Steam Generating	Electrical	Instruments	Miscellaneous Plant
Chemicals	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ceramics, Brick, Clay Prod.	X	X	X	X		X	X	X		X		X	X	X		X	X	X	X
Coke	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Drugs, Medicines & Cosmetics	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Explosives & Fire works	X	X	X	X	X	X	X	X	X				X	X	X	X	X	X	X
Fertilizers	X	X	X	X	X	X	X	X		X			X	X		X	X	X	X
Glass	X	X	X	X			X							X			X	X	X
Gelatin, Glue & Adhesives	X	X	X	X	X	X		X					X	X		X	X	X	X
Leather, Tanning & Finishing	X	X	X	X	X	X							X	X	X	X	X	X	X
Lime and Cement	X	X	X	X		X	X	X		X		X	X	X			X	X	X
Gas, Manufactured	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Oils & Greases	X	X	X		X	X		X	X		X	X		X	X	X	X	X	X
Paints & Varnishes	X	X	X	X	X	X	X	X		X			X	X		X	X	X	X
Paper & Pulp	X	X	X	X	X	X	X	X			X		X	X		X	X	X	X
Petroleum Refining	X	X	X		X	X		X	X	X	X	X		X	X	X	X	X	X
Rayon	X	X	X	X	X	X		X			X		X	X	X	X	X	X	X
Rubber	X	X	X	X	X	X							X	X	X	X	X	X	X
Soap	X	X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X
Sugar	X	X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	X
Other Process Industries	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Chemical & Metallurgical Engineering
Market Research Dept. 1929

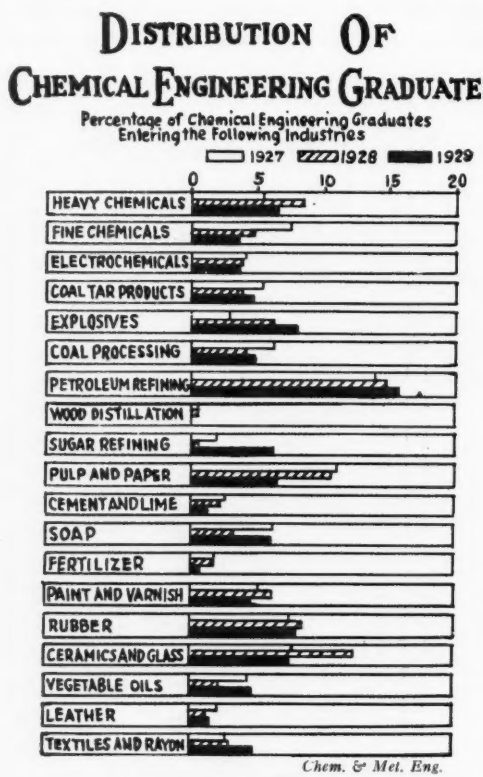
TABLE III

out which enables the well-trained chemical engineer to serve with equal success any one of the various industries listed. This condition gives unity to the chemical engineering profession.

It is interesting to note that in recent years the petroleum refining industry has been the largest single employer of chemical engineering graduates. A study made by James A. Lee (*2*) showed that 15 per cent of the 741 graduates in chemical engineering in 1929 entered the petroleum industry. Heavy chemicals, explosives, pulp and paper, sugar refining, soap, ceramics, and glass each took 5 per cent or more of the total.

It should also be noted that the wood distillation industry employed the smallest proportion. While the petroleum industry has been one of the most prosperous, the wood distillation industry has been threatened with extinction on account of the competition by the products of other more technical industries.

The chemical engineer's principal contribution in each of these fields of industry is in production. He may design and construct a plant but most of his time is devoted to operation. Therefore a great many of the chemical engineers in industry today have titles of supervisors, department heads, plant superintendents, production managers, etc. There was a time when the chemical engineer's only entrance to the production organization was through the laboratory. Today many, if not most, men enter as cadet engineers, shift supervisors, assistant foremen, and the like. There is no royal road to success for the chemical engineer, but because the production man "makes the wheels go round," he becomes a most essential part of industry and his opportunity for advancement to executive responsibility is correspondingly large.



Chem. & Met. Eng.

TABLE IV

The work of the chemical engineer in developing processes is of very great importance. In many of the larger and more integrated industrial organizations, there is a distinct division of work between the research chemist on the one hand and the research engineer and development man on the other. The chemist commonly conceives the process and demonstrates it on the laboratory scale. The chemical engineer takes the labora-

tory process, proves and develops it first in the semi-works, then in the full-scale unit, and finally in the commercial plant. In smaller organizations, chemical engineers are often selected for chemical as well as engineering research. This is primarily because of the flexibility that makes the chemical engineer adaptable to the solution of both chemical and engineering problems.

The opportunity for the chemical engineer in technical research is second only to that in production. His rise may be equally as rapid, despite the fact that research, unfortunately, is not universally recognized as an indispensable department of all industry. And not until research is planned on a long-term basis, with a definite financial reserve set up to take care of it, will the research organization have the same security and stability that is found in production work.

Another very important part of the work of the chemical engineer is in the field of economics. Just as industry succeeds only as it makes a profit, so the chemical engineer is vitally concerned with the economic bases of industrial operations. Before a process from the research laboratory can be translated into successful commercial production, some one must carefully study its economic feasibility—its primary utility as compared with existing processes and practices. This gives rise to a great and growing opportunity for the chemical engineer. Likewise the same methods are applied to the study of industries themselves—by chemical engineering advisors for investment trusts, banking houses, etc.

Because the market for the product of a chemical engineering process determines its success or failure, the chemical engineer is often called upon to study chemical (as contrasted with chemical engineering) economics. He must know the methods and principles of market analysis, costs and prices, studies tariff and freight rates, and many other factors that in their aggregate have come to be known as the field of commercial research. This field is relatively new but it is growing rapidly, especially as the business depression has put a premium on the more scientific aspects of industrial marketing.

These opportunities for the chemical engineer in industry all lead eventually into executive work for the man who is willing to take over the responsibilities of direction and supervision. And because the engineer has been trained to get his facts and base his conclusions and action on such data, rather than on guess-work or hunches, he is most often successful, particularly in a technical enterprise. We must not forget, too, that these process industries, with their constantly changing technology, require a better appreciation of the intimate technical detail and possibilities of the job and of the industry as a whole. Hence the increasing number of so-called "technical executives."

A limited number of chemical engineers must be engaged in teaching this

subject in the institutions which offer courses in this subject. As chemical engineering requires a knowledge of both scientific principles and plant practice it is essential that the men who teach this subject should have had a number of years of practical experience in plant design or operation before undertaking the teaching of this subject. Most professors of chemical engineering also have the opportunity of practicing their profession as consultants in some branch of chemical engineering. This work serves to keep the professor abreast of the most recent progress in the subject which he teaches and also serves as a very desirable supplement to his academic salary which is not always adequate. However, the eminently practical character of chemical engineering education calls for high-grade men, and in most institutions, salaries are correspondingly high. The university laboratories offer further attraction for chemical engineers to carry on research and development either independently or with the coöperation of an industry. Certainly the man interested in chemical engineering as a career does not want to pass up these opportunities without a careful consideration of the intangible as well as the tangible values in teaching.

The compensation received by the chemical engineer is comparable with that received by engineers in other fields doing work of corresponding importance or occupying positions of equal responsibility. The initial annual salary of the young man graduating from the usual four-year course will be from $1500 to $1800. The graduate with a master's degree will receive a somewhat larger compensation ranging from $2000 to $2400, while the man having a doctor's degree will receive from $2400 to $3000. In from five to seven years this compensation is usually doubled.

Under normal business conditions it is frequently possible for the young chemical engineer to choose the industry in which he prefers to work. In spite of the high state of efficiency to which many of the chemical industries have been brought, most of them still offer many opportunities for further development and improvement by the chemical engineer. Even the petroleum industry which has recently absorbed so many chemical engineers has many problems for which an early solution is demanded. It may be of interest to list some of them.

The Corrosion Committee of the American Petroleum Institute reported that the evidence obtainable indicated that the annual loss to the petroleum industry from corrosion alone, in the field, pipe line, storage, refining, and marketing reaches the enormous figure of $125,000,000 annually. It is undoubtedly possible to reduce this loss materially. The estimated fire loss to the industry was $1044 per minute in 1925. The aggregate of this loss is much greater than that from corrosion, the prevention of which offers a very promising field for the chemical engineer.

A billion gallons of gasoline is lost every year by evaporation in handling and storing this volatile product. This loss starts as soon as the petroleum

is pumped out of the wells and continues during the manufacturing process, storage, and transportation of the gasoline. The evaporation loss has been reduced by a number of improvements in the industry. These include the selection of the most suitable paint for the storage tanks as well as floating roofs for these tanks.

The most revolutionary process introduced into the petroleum industry has been the Bergius hydrogenation process by which heavy oils and residues may be converted into more valuable lubricating oils and gasoline. By means of this process it is possible to convert 100 per cent of the petroleum into valuable products, it being also possible to produce any desired proportion of any given product. This gives the industry a flexibility which it has lacked in the past. This process is at present in the development stage and requires much technical work for its installation, adaptation, and operation.

The magnitude of the industry is indicated by the fact that in 1926 12,500,000,000 gallons of gasoline were used. The tremendous waste of our natural resources is indicated by the fact that in the operation of an automobile only 5 per cent of the energy of the gasoline is actually utilized in pushing the automobile. Here is a most fertile field for research and improvement by the chemical engineer.

I have mentioned only the larger research problems awaiting solution in this industry. The highly complicated processes which are being installed in this industry will always require a well-trained staff of operating engineers among whom the chemical engineer will always have a prominent place. The rule holds true for all chemical industries that active research development will always call for a corresponding complement of well-trained operating staff.

Another industry which illustrates the importance of the service which the chemical engineer may render is that of wood distillation. This industry is relatively old, the methods first used having been very primitive. While improvements were gradually introduced, progress was not as rapid as in many other industries. This was partly due to the fact that the plants were scattered and generally relatively small so that any single plant was not able to bear the expense of extensive research and development.

In addition to charcoal, the most important products were calcium acetate and methyl alcohol. The most important use for calcium acetate was the production of acetic acid. Within recent years synthetic methods for the production of acetic acid and methyl alcohol at very low cost have been developed. As this threatened the existence of the wood distillation industry, it was necessary to modernize the processes used and reduce the cost of manufacture of the products in order to save the industry.

When called in for this purpose the chemical engineer found many features of the processes which could be greatly improved. The first

operation which the wood distiller carries out is the removal of about half of the moisture content of the green wood. The recently felled wood contains from 40 to 50 per cent of moisture which must be reduced to 20 to 25 per cent. The method formerly employed for this purpose was to allow the wood to remain in the open air until dry. This required from twelve to eighteen months. It was therefore necessary for the wood distiller to carry on hand at all times from one year to eighteen months' supply of wood.

When the chemical engineer had modernized this process the wood was dried in a tunnel drier using waste heat, the green wood being fully dried within forty-eight hours. As the dried wood passes directly from the drier to the retorts it enters the retorts already heated to the temperature of the drier. This was found to be of considerable advantage in the carbonizing process. The temperature of the retorts is carefully controlled so that the best conditions for carbonizing are always maintained. This gives the highest yield of valuable products.

It was found possible to improve greatly the distillation process for the separation of the alcohol and acetic acid so that a higher yield and a purer product was obtained. The necessary evaporation is now carried out in multiple effect evaporators using exhaust steam. It has also been found possible to extract acetic acid direct from the pyroligneous acid and even to produce glacial acetic acid by this process.

As a result of these and other improvements it has been possible for the chemical engineer to rescue an industry from extinction. Many other technical processes needing improvement and modernization await the services of the chemical engineer. Only those industries whose managements realize this fact and avail themselves of the services of the chemical engineer will long survive modern competitive business conditions.

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(*1*) PARMELEE, *Chem. & Met. Eng.*, **35** (Jan., 1928).
(*2*) LEE, *ibid.*, **36**, 415–6 (July, 1929).

Disguising Bitter Taste of Strychnine with Yerba Santa. An extract of a plant called *yerba santa* or mountain balm was found to be the most effective of several chemicals in disguising the bitter taste of strychnine, Justus C. Ward and James C. Munch of the U. S. Bureau of Biological Survey have reported to the American Pharmaceutical Association. The latter drug, while it is a very strong poison, is used medically in very small amounts, chiefly as a tonic.

Salts and sucrose also masked the taste of the strychnine, but to a less extent than *yerba santa*. Sodium bicarbonate, on the other hand, increased the bitterness. Taste buds for detecting bitterness are located on the tip as well as on the base and sides of the tongue, the investigators reported.—*Science Service*

STUDENT MEETINGS OF THE INDIANA SECTION OF THE A. C. S.*

WILLIAM HIGBURG, REILLY CHEMICAL COMPANY, INC., INDIANAPOLIS, INDIANA

The Indiana Section in 1922 conceived the idea of contributing something to the chemists of Indiana by staging what is now officially called a "Student Meeting." In this biennial meeting the junior and senior students in chemistry from all of the colleges in Indiana are brought to Indianapolis with a three-fold method of approach toward the single purpose of the meeting.

The whole purpose of this meeting is to acquaint the embryo chemists of the state with the chemical industry, particularly the chemical industry of Indiana, and to give them assistance in finding their proper place in the scheme of chemical development. The three-fold method of approach consists first, in presenting exhibits of industrial chemical enterprises; second, the arrangement of inspection trips to various chemical industries in and about Indianapolis; third, the providing of competent speakers to advise and confer with the students on such subjects as industrial research, post-graduate research, methods of approach in seeking connections in the industry, and such kindred subjects as particularly interest a young man who is about to step from his Alma Mater into the cold dawn of the necessity of earning his own daily bread. The mechanism of the meeting is covered and the beneficial results of conducting this type of meeting are pointed out.

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It is obvious from examination of the preliminary program of the Division of Chemical Education in the present meeting that our readers in scientific training are giving serious thought and attention to bridging the gap between the classroom, chemical laboratory, and the practice of the chemical profession in industry. There is real need for continuation of such thought and attention.

Many of those who completed their chemical training fifteen years or more ago, will remember that a course in chemistry consisted principally of the usual qualitative and quantitative analyses, general, physical, and organic chemistry, with language, mathematics, and electives rounding out the curriculum. Chemistry then was a field in which the primary goal was largely confined to the teaching profession or to routine testing or developmental work in municipal government or industrial laboratories.

Little emphasis was placed upon industrial research work nor was the mind of the student often or purposely diverted to the opportunities of applying his science to problems of industry. There were courses offered in which chemical reactions in processes were propounded but not with the intent to induce interest or stimulate ambition of the student to design more suitable or less costly methods for accomplishing the same result.

* Contribution to the symposium on "Coöperation between Industry and Chemical Education," held under the auspices of the Division of Chemical Education, at the 81st meeting of the A. C. S. at Indianapolis, Indiana, March 31, 1931.

With the advent of the World War conditions were changed. Chemical materials were needed and many were not to be had. The chemist had to produce them and produce them he did. The teacher and the laboratory worker joined together and founded the beginnings of a chemical industry built with such solidity that it cannot now be displaced.

The result has been a continued zeal in the application of science to industry. Our instructors and professors do not now content themselves with their efforts to inculcate fundamentals. Practical applications are cited at every turn of the page and the student of chemistry is now, more than ever before in the history of our chemical teaching, learning theory and practical application out of the same book. An attempt is made to afford a most intimate contact between the student and all the possibilities of his chosen profession. Practical courses are given in a number of schools and in other institutions the student alternates in intervals of six or eight weeks from his chemistry to commercial apprenticeship and then back to his chemistry and schooling again.

In many institutions not conveniently situated in close proximity to commercial and chemical plant processes there arises a problem of how best to supply this close contact with industry. Extended trips and visitations are limited to those students who are able to afford the required outlay of time and money. The visitation trips themselves may be limited to the mere routine of a cursory inspection if proper coöperation on the part of the plant management is lacking.

If now instead of the student seeking to contact himself with industry, it were arranged that the chemical industry itself elected to contact with the student and his instructors, would not the problem be much simplified? If it were evidenced that industry and commercial science were willing to give every aid and assistance to the student and his faculty, would they not be eager to avail themselves of every possible opportunity for such contact and association?

It was in 1921 that the executive committee of the Indiana Section first propounded these questions to our group of local members. Action was not long delayed. With a realization of a need to be filled and a vision of a service that might be rendered, there was instituted in the spring of 1922 what is now known as the "Biennial Student Meeting of the Indiana Section." The physical mechanism of the meeting as it has been established and approved through the experience of five meetings is as follows. Junior and senior students in chemistry, together with the chemical faculty of the twenty to thirty colleges in Indiana, are invited to Indianapolis for a two-day meeting. The fixing of dates for this meeting has so far been regulated by adopting Friday and Saturday of spring vacation week. The registration fees for visiting guests have ranged from one dollar to two dollars and fifty cents. This fee includes three gratuitous meals, one or

two of which are complimentary luncheons arranged through the courtesy of the management of plants being visited. Registration is held early on the morning of the first day and is followed immediately by a series of inspection trips to chemical industries. The registrants are convened at noon for a luncheon at which a speaker is heard. Further inspection trips follow in the afternoon. In the evening the official convocation is held and the group is addressed by a guest speaker.

On the morning of the second day more inspection trips are scheduled and at noon another luncheon and speaker are presented. In the afternoon there is arranged a symposium for the students (but also attended by the faculty) at which the chemist and his job are dealt with in a frank and open manner. On the afternoon of the first day a faculty colloquium is scheduled in which problems facing the teaching profession are discussed. Exhibits covering a variety of chemical industries not reached through inspection trips are arranged at the meeting headquarters. At some meetings several local section members appear as speakers before the students. Throughout the whole meeting the students are encouraged to meet, contact, and become acquainted with local section members.

Opportunity is thus afforded for passing on the opinion and experience of the older professional men to the younger. Inspection trips are supervised by local members and are carefully arranged. Every consideration is given to making all features of the meeting of most advantage to the students. It is a "Student Meeting" in name and in fact.

The planning of each Student Meeting begins in November or December of the year preceding the meeting with the appointment of a general Student Meeting Chairman by the chairman of the section. The general chairman then selects various committee heads for handling each one of the separate activities that merge into the complete and final program as presented. Attendance exhibits, inspection trips, registration, speakers, guest reception, publicity, are all functions so handled by individual committees or committeemen. Every detail of the meeting is so carefully worked out that the visiting groups are kept continually busy from the time of registration on Friday until 3 or 4 P.M. of Saturday when the meeting is adjourned.

Now what has been accomplished? In our 1926 meeting we told the students they should come to the meeting, because:

1. You will see exhibits covering all types of chemical industry.
2. You will see plants in operation under chemical control.
3. You will be addressed by men who have had years of experience in chemistry as applied to industry.
4. You will come in contact with men in the profession who are ready and willing to meet you and help you.
5. You will be helped in choosing for yourself the branch of chemical endeavor in which you belong.

6. You will meet and exchange ideas with fellow students from other schools.
7. Your expenses at the meeting will be small.
8. You cannot afford to stay away.

In a two-day session we have shown through inspection trips and exhibits, the chemistry and manufacture of pharmaceuticals, vaccines, toxins, tires and rubber goods, storage batteries, gas, benzol, ammonia and by-product coke, creosote oil and coal-tar products, carburizing compounds, disinfectants, solvents and fermentation processes, enamel ware, lubricating oil and gasolines, canned foods, decorative tile, milk products, silk hosiery, glassware, paper, and other processes of equally wide and divergent varieties. We have presented local section members who have given the students a view of the problems faced in their own particular fields. We have offered intimate contact between our local members and the students and have attempted to answer questions regarding our particular positions within the chemical field.

We have attempted to give a picture of the advantages and disadvantages of each of the general fields of endeavor open to the chemist who is ready for graduation. We have sought to make available the advice of honest and capable men who could, for example, counsel clearly concerning the value and advantage of advanced degrees in best qualifying for industrial chemical research. We have held confidential meetings in which have been discussed the proper method of approach in securing a position, how to write letters of applications for positions, and what should be said and done if the stipend offered for services is not sufficient to meet expectations. We have had presentations of the opportunities in organized industrial research as exemplified by the activities of the Mellon Institute. Best of all, the students have been given inspiration from the lips of leaders in chemistry and successful chemical industrialists. They have, for example, been given the story of the romantic career and persistent efforts of William Hoskins, the story of research and its development as pictured by Dr. Lind, the pioneering in industrial research and the examples of successful effort as pictured by Dr. Beal and Dr. Weidlein—and the determined aggressive teaching and advice voiced by our good friend Otto Eisenschiml who drives home real practical messages in such texts as the following: "get the problem, solve the problem, but most important of all, sell the problem at a profit."

The Indiana Section has been gratified in the results of these meetings. We have been delighted with the enthusiastic vigor of the faculty meetings, with the real interest taken by the students, with the questions that are asked by them, with the grouping of students about our speakers for further discussion after the meetings have been adjourned, and with the reports that have come to us from faculty and students as each meeting has been concluded.

Nor have the benefits all accrued to the visitors in attendance. The section has gained greatly in a thorough training in planning and executing these meetings. We have in handling these groups of 250 to 400 persons, learned something of the mechanism of such meetings which we trust may reflect itself in the preparation and handling of the national meeting in which we are now engaged. Further than that, our local members have been broadened by contact with students, professors, and visiting guest speakers. We have had the pleasure of occupying ourselves in a task which we feel has been worth the doing. We are hopeful that we have in some measure increased the usefulness of our local organization and that, as a part of the American Chemical Society, we have contributed some little good to the chemists and chemistry of tomorrow.

UNITED STATE CIVIL-SERVICE EXAMINATION FOR PRINCIPAL METALLURGIST

The United States Civil-Service Commission announces an open competitive examination for the position of principal metallurgist. Applications must be on file with the U. S. Civil-Service Commission at Washington, D. C., not later than July 24, 1931. The examination is to fill vacancies in the Bureau of Mines, Department of Commerce, for duty in Washington, D. C., at Pittsburgh, Pa., or elsewhere in the field. The entrance salaries range from $5600 to $6400 a year.

Competitors will not be required to report for examination at any place, but will be rated on their education, training, and experience. Applicants must have been graduated with a bachelor's degree, with major work in metallurgy, from an institution of recognized standing, and subsequent to graduation must have had at least three years of professional experience, college teaching, or post-graduate college training in metallurgy or metallography. Certain additional experience is also required.

Full information may be obtained from the Secretary of the United States Civil-Service Board of Examiners at the post-office or customhouse in any city or from the United States Civil-Service Commission, Washington, D. C.

Next to Nothing. 0.00000000000000001 ampere, or about 63 electrons per second is an electric current difficult to visualize, and, before the development of a new electron tube, difficult to measure. The difficulty lay in the uncontrollable current variations within the vacuum tube used for measuring. The possible error was greater than the current to be measured. Intensive study of the cause of the objectionable currents, chiefly from the grid, has led to their elimination or reduction, and another example is seen of the electron tube's widening range of usefulness and increasing efficiency. The new tube can be substituted for the electrometer, a complex instrument now used in the determination of very small voltages and currents. Photoelectric cell work will be made more accurate where the light quantity is very low, as in studies of the heat radiated by the stars or variations in their brightness.—*Ind. Bull. of Arthur D. Little, Inc.*

THE EFFECT OF CHEMISTRY IN THE DEVELOPMENT OF THE SOUTH*

UNITED STATES SENATOR PAT HARRISON, OF MISSISSIPPI

Allow me in the beginning to express my appreciation of the courtesy of the invitation by which I am permitted to address you. Although for some two decades I have constantly come in contact with the administrative officers of your institution, accepting their counsel and coöperating when possible, always feeling a keen pride in your progress and achievements, it has not been my pleasure until now to address your student body. And on this occasion, if I should follow my first inclination, I would discuss with you some of the great political questions that now confront our state and nation.

But I am not going to do that. I am going to talk to you today on a subject that is interwoven in the economic life of our section and in which her leadership must be exerted. In doing so I shall attempt to employ no glossy phrases or rhetorical flights, but merely engage you in a practical discussion of a subject that has been a greater influence in the progress of our section than any other: "The Effect of Chemistry in the Development of the South." And if I can sketch a picture that even in a small way may attract your attention and interest in its continued advancement, then I shall feel my visit here today well paid.

Do not understand me to assume any special knowledge of chemistry. I know little about its fundamentals, or the principles upon which it operates. If there was one subject during my school days which I detested, and from which at every opportunity I fled, it was chemistry. I used to think that any one who would study it and make an attempt to master it would inevitably find himself under the ministering care of some state institution.

My observation and study for many years as a member of the Agriculture and Finance Committees of the Senate, however, delving into the problems of agriculture, reforestation, and tariff construction, have led me into a strong realization that chemical research and chemical application have wrought wonders and are destined to be still greater forces in the progress of the world.

Before the World War the South, as well as the country, had developed with marvelous rapidity, but that development had largely come through the genius of our people and the unrivaled richness of our natural resources. When the World War came we found ourselves impotent to cope with our adversaries in the science of chemistry. Nitrates, from which explosives were made, and which we had purchased from Chile, we could not supply. Many medicines, necessary for the preservation of the health of our civilian population and the soldiers at the front, and dyes, essential to

* Baccalaureate address delivered at the Mississippi Agricultural & Mechanical College, Agricultural College, Miss., June 9, 1931.

our textile industries, were cut off for the reason that they were either controlled by foreign peoples or not produced here. Innumerable patents needed in the prosecution of the war and economic life of the nation were also under the domination and control of foreign governments. The German Empire, through subsidized scientific research in her many agencies of learning, had given to the world a group of distinguished scientists, unrivaled by any other nation, and held such a dominating position in chemical advancement that we found, as many of our allies found, unless some change in our national policy was immediately employed and the genius of our manhood and an abundance of our capital applied to chemical science, we could not possibly win the war.

It was in these circumstances, under the leadership of the great War President, whose talents and memory and achievements we all revere, that the country then began, in a degree never contemplated or dreamed of before to embark upon chemical research that we might supply for ourselves those things which we needed, not only in the prosecution of the war, but essential to the very life of the nation.

No finer tribute can be offered to the genius and ability of our people to meet every emergency, than the immediate application and unrivaled progress made by them in the last few years in the science of chemistry. Our educational institutions, as well as industrial institutions that had formerly paid little attention to chemical research, changed their policies. Budgets were enlarged and capital provided. Young men began to experiment. Scientists began their investigations. Chemical laboratories were constructed everywhere, and in a little while we were startling the world with our new discoveries, until today we rank foremost among all the nations in chemical science.

If you should ask me what in my opinion is the key to the industrial advancement of America, I would answer you that it is the progress and achievements of chemistry. There is hardly an industry that is not dependent upon it, and certainly there is no industry but that is related to it. It is said that agriculture is the basic industry in our country. It is. When agriculture is prosperous, it is reflected in the progress of other industries and in the prosperity of the country. When it is depressed, its effect is conversely true. And yet, agriculture, aside from the human energy and intelligent application of the individual farmer, is dependent upon chemistry. All lands are not as rich as those that border the Nile or lie in the bosom of our own Delta. They need nourishment, that life may be extended and better results obtained. I have stated that only a few years ago we were dependent upon Chile for our nitrates for war purposes. We were just as dependent upon Chile for our nitrates for food for our soil. Today, under the guiding hand of chemistry and the employment of our great natural resources, we are producing, and will continue to expand our

production of nitrates, potash, phosphates, and every other kind of fertilizer necessary to preserve and enrich our farm lands.

Chemistry has so transformed the manufacture of these essentials to crop production that they are even making nitrates from air without the assistance of electrical energy. The erection of these plants in many places in the South and the certain utilization in time of our great natural resources at Muscle Shoals will not only supply the nitrates necessary for our Nation's consumption, but will do it at greatly reduced costs.

I sometimes think that if we didn't have so many botanists, we wouldn't discover so many pests and insects to invade and destroy our crops! But it is a fact from which we cannot retreat, that crops of every character, from wheat to corn, cotton to tobacco, are constantly being invaded by new pests and strange insects which must be checked and destroyed. It was the application of calcium arsenate that won the fight against the boll weevil and saved the cotton crop of the South. It is to the science of chemistry that we have looked and to which we must look for new discoveries to preserve and protect these crops.

If there is ever to be applied a plan of orderly marketing of many of the products of the soil, so that the producer can get a fair return for his efforts, it will come in a large part through the application of chemistry in preserving those products over such a length of time that the markets can absorb them.

The relationship between chemistry and agriculture is no greater than between chemistry and all the other great industries. I shall not multiply illustrations, but my reason for discussing the subject, "The Effect of Chemistry in the Development of the South," is particularly because of the South's great natural resources, water power, climate, forests, minerals, and raw agricultural products.

In this age of complex and pronounced scientific progress, when the science of utilizing raw materials and manufacturing them into various products, essential to industry and the economic life, the South cannot possibly make the most of its strategic position by being content to transport these raw materials into other sections or other countries, there to be transformed into different and finished products. If industry is to prosper, then every short cut should be taken in the varied steps through which it passes from the producer to the market. When we look around and vision the many things we see, from oak forest to desk, from raw cotton to clothing, from pine tree to pencil, from slate to blackboard, we can realize how much of our raw material is being transported to other centers, there to be made into the finished product and returned to be sold to us. It takes no stretch of the imagination for us to be convinced that our progress will be best promoted if we can utilize at our own base these enormous raw materials, here transforming them into the finished product and shipping

them without, to be sold in the markets of the world. It is money being returned instead of money going out.

In that transportation process capital is essential. We cannot close our eyes to the fact that we do not have in the South the amount of waiting capital necessary for the full development of our raw materials. It is a wise policy, therefore, that while our state governments should be ever guardful of the people's interests, yet at the same time realize that if capital is to come to us, prudent and fair legislation must be enacted so that it will be assured of rational protection and sympathetic coöperation. I say that in no spirit of criticism of our own state government, because it is my belief that, as a whole, our state offers as inviting a field for invested capital as most of the states in the Union. I merely cite that in order to emphasize the fact that many influences are to be considered in the industrial development of a section.

I appreciate the fine advantages offered by our state for agriculture, horticulture, and dairying industry. But there is no conflict in the progress of those industries with that of other industries.

Industrialism is the scientific master of the raw material and its wise disposition according to the laws of trade. It is difficult for the mastery to be acquired unless we have the fuel as well as the raw materials. Chemical transformation takes effect at elevated temperatures. Climate plays a tremendous part. The South is blessed with not only an abundance but a varied supply of fuel, adequate to meet every demand. We have solids, liquids, and gaseous fuels. Our unbridled streams await to be harnessed that electrical current might be transmitted. Her bosom is heavy with untouched tons of coal. Oil flows from her almost every pore, and new gas wells are springing up daily. Already the oil and gas industry of the country has its eyes turned toward Mississippi, while at Jackson and at Amory we have already discovered it, and they are making enlarged and greater uses of it. The time is not far distant when still greater discoveries will be made and Mississippi will be one of the great oil- and gas-producing states of the Union.

While we have witnessed a veritable renaissance in the last decade in the South, we are now plunged into what chemists call an age of cellulose. Vast industries depend upon it as their raw material. What may be the by-product of one industry may be the raw material of another industry. It is through the processing of so many products that chemistry has utilized every waste in creating by-products. In processing steel through its various steps, hundreds of alloys and by-products are made, which are necessary in the manufacture of other products. In former years in the making of sugar from sugar cane, there was produced what was known as blackstrap. It was believed to be useless and was discarded as waste. Chemical science has pointed the way for its use as a great foodstuff and in the

manufacture of alcohol. There is another sugar cane waste product known as bagasse, which through a chemical treatment is called celotex, and is a product known around the world and used in the construction and finishings of buildings, bringing millions of dollars annually to the sugar industry. In recent years we have gradually reduced the importation of starches from foreign countries because chemical science has developed a starch from corn, Irish and sweet potatoes, which is destined in time to dominate the starch market.

Only a few years ago when cotton was extracted from the cotton seed, the seed was thrown away as useless, and with it the most valuable and important portion of that crop. This once discarded waste has now, through the work of chemistry, become the most valuable part of the cotton industry. In the cottonseed oil mills the cotton fibers remaining on the cotton seed after the original ginning are still further removed and the linters thus produced now constitute the raw material used in the manufacture of gun cotton, pyroxylin, celluloid, artificial leather, and a host of other products which are daily becoming more and more a part of our every-day existence.

After removal of the linters the hulls are separated from the meats of these hulls, so long utilized only as a roughage for cattle feed, and a most interesting sugar has been produced. From the meats, by hydraulic pressure, cottonseed oil and cottonseed meal are obtained, producing the best grade of olive oil and lard, as well as the highest value of foodstuff for cattle, and fertilizer for the rehabilitation of the soil. Scientists have found a protein in the cotton seed that is so valuable to human life that delicious and nutritious foods are being made and marketed.

In China it has been the slow work of the worm and the spider, weaving industriously day and night for generations, that has produced the silks that our men and women have worn. But the chemists are about to put the silk worm out of business, through the application of cotton and wood cellulose, taken from the refuse of our forests, in the manufacture of a rayon that has all the appearance and durability of silk. Today there is invested in the South in the manufacture of rayons millions of dollars and the human mind cannot conceive the end of that development.

I doubt if any industry has progressed more rapidly, because of the great strides taken in chemical research, than has the packing industry. Our wonderful grazing lands and fine climate offer an inviting field for dairying, and the fact that chemistry has made it possible for the economic manufacture of milk and butter and cream preparations, as well as the disposition of hoofs, horns, hair, bones, and even the blood of cattle into useful articles, its benefits have been reflected upon the dairymen and stock grower.

The textile industry has come South, because of the raw materials here, and the admirable conditions offered that industry by our section. In

cotton manufacturing alone hundreds of millions of dollars are now invested, and new plants are being constructed all the time.

In the manufacture of paper, the glossy perfection is influenced through the chemical application of casein. It has been believed by these paper manufacturers that only the casein made from skimmed milk of Argentine cows could be used. But now chemistry has discovered that casein made from the skimmed milk of our own American cows will answer the purpose.

Few states have been richer than Mississippi in fine and virgin forests. For the most part these timbers have been cut and in the process untold millions have been wasted in the destruction of unused and rejected parts. Chemistry has discovered that every part of the tree, from stump to limb, can be made useful and profitable. Chemistry has made the startling discovery that lands in the south, and particularly in Mississippi, can produce trees for wood pulp purposes within ten to twenty years. In New England it takes sixty years, and in the northwest, seventy-five years to produce trees for like purposes. Within the last decade scores of paper factories have been established in the South, invited here by the opportunities in the economical production and acquisition of the raw materials. Today, under scientific leadership, stumps are economically taken from the ground, clearing the land for cultivation. Rosin and turpentine and innumerable other by-products, essential to the economic life of the Nation, are extracted from the stump. Not only is the saw log manufactured into lumber, but every particle of saw dust and tree limb, once hauled away as useless, is turned into vats to be manufactured into finished products. A few years ago there was established at Laurel, in our State, what was known as a Masonite Factory. It has progressed and prospered beyond the dreams of its founders. It gives employment to hundreds of people and has become almost a staple product throughout the country. That product is made from saw dust, limbs, and waste from the lumber mills, and is a high-priced finished product, used in the construction and beautification of offices and homes.

Rosin and turpentine, which are Southern raw products, are essential not only for medicinal compounds, but for varnishes and paints and many other necessities. There has been discovered recently, for the safety and protection of human life, an unbreakable glass. It is only a question of time when it will be used in every automobile and Pullman car. This glass is made from pyroxylin, the essential ingredients of which are cotton linters and synthetic camphor. Synthetic camphor is made from turpentine. We have and are today importing practically all of our synthetic camphor from Germany, and this synthetic camphor is made from the turpentine we sell and ship to them. It is but a question of time until ambitious American capital will invest here, so that these two great Southern raw

materials may be manufactured into the finished product, freeing our country from dependence upon Germany.

And so it is well that we should retrospect upon these great advancements that have been made in our industrial life, and face the future with some degree of optimism. We have the natural resources. We are blessed, as no other section is blessed, in the countless and unlimited character of our raw materials. We have clays, sulfur, salt, iron, bauxite, and innumerable other raw products and are dependent upon no other section for our supplies. In other countries and in other sections of our own country, increased expenditures for new and enlarged chemical laboratories are being made, not only by the progressive industries themselves, but by the states and their educational institutions. If the South, and Mississippi, in particular, is to take advantage of these great opportunities, we must keep pace with the progress of the day and be alive to every opportunity.

I want to congratulate your institution on the progress you have thus far made and to express to you the hope that in the future the State and you will take greater and more enlarged interest in the advancement of scientific chemistry. To you, young gentlemen, who today sever your connection as students of this institution, and go into the walks of life, let me adjure you, whether you intend to walk into the paths of chemical science and research, or be employed in some way or another with industries upon which chemical science has furnished the basis of their progress and prosperity, that you take a greater interest in the subject, because upon it, above all else, does the stability and further development of the South depend.

I want to see a still greater industrial awakening in the South than we have yet experienced. With our great natural resources and unrivaled supply of raw materials, it will come, if we but supply the proper interest, coöperation, and enthusiasm.

Neodymium, Rare Element, Gives New Kind of Light. Rods of quartz heated in the Bunsen burner have been made to send out a new kind of light, the National Academy of Sciences was told recently.

The quartz, in which a compound of the rare metal neodymium had been dissolved, was prepared by Prof. R. W. Wood of The Johns Hopkins University. When heated the rods give a light whose rainbow or spectrum does not include all the colors but is crossed by dark bands.

A white-hot, incandescent wire, like those of tungsten used in the electric lamp, gives white light in which none of the possible colors are missing. The neodymium, however, has the unique property of sending out only special vibrations of its own. Light passed through cold neodymium or other rare earth compounds has these same colors removed from it. No other substance shows this peculiar behavior.—*Science Service*

CHEMISTRY CURRICULUM FOR TEACHERS' COLLEGES

J. W. Neckers and T. W. Abbott, Chemistry Department, Southern Illinois State Teachers' College,* Carbondale, Illinois

An advisory four-year course for chemistry majors in Teachers' Colleges is presented. A minor in mathematics, with other possible minors in physics, history, or literature may be had by following the schedule. The course as offered is of sufficient thoroughness for a preliminary to graduate work for an advanced degree. Some of the difficulties attending the work for a Bachelor of Education degree in the science are discussed.

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In this day of experimental methods and systems of education and of rapidly changing requirements for high-school teachers of science, there might be interest in the presentation of a curriculum for chemistry majors applicable to a Teachers' College. The American Association of Teachers' Colleges has had a decided influence in the last several years in raising the standard of work presented in the four-year pedagogical colleges, especially through elevated requirements regarding equipment and the qualifications of the teaching staff. There seems to be a definite trend toward giving prospective high-school teachers material on *what* to teach as well as *how* to teach.

In arranging a curriculum for majors in chemistry in a Teachers' College, therefore, certain factors must be considered that are not so vital in Liberal Arts and Science Colleges. First of all, Teachers' Colleges have as their primary function the training of teachers. To fulfil this requirement considerable time must be spent in training the students in the fundamentals of the art of teaching. This, of course, coupled with the requirement of a number of unrelated subjects for a broader preparation, limits the number of elective courses that the student may take, and makes more necessary a definite arrangement of courses so that he may meet all the requirements for graduation. This will be appreciated more fully when it is realized that this school answers the specifications of a Liberal Arts and Science College, being an accredited member of the North Central Association of Colleges and Secondary Schools, and at the same time its graduates qualify for certification in all but one of the forty-eight states.** For these reasons a carefully prescribed course must be followed for the student to be able to answer the customary Liberal Arts and Science requirements plus those of pedagogical standards.

To that purpose, with the coöperation of the administrative and advisory forces, an advisory course has been compiled for the guidance of chemistry majors. Various minor changes have been made since it has gone into effect,

* A new chemistry laboratory in this college was formally opened on February 26, 1930. See J. Chem. Educ., **7**, 1208 (May, 1930).

** California requires a period of residence study in one of its teacher-training institutions before certification.

and the course as presented is one which seems to answer all present requirements. This curriculum has been in operation here for the past two years and is given full recognition in all the universities of the North Central Association. Degree students from this institution have been admitted for graduate work with full standing to the University of Illinois, the University of Michigan, and the University of Iowa, among others.

The term system of twelve weeks each is followed for several reasons, chief of which is that it makes possible the division of the year into four equal quarters for the accommodation of the large number of employed teachers who desire maximum summer work. Each class meets four academic hours each week, yielding four quarter hours of credit. One quarter hour is the equivalent of two-thirds of a semester hour, following from twelve instead of eighteen weeks per session. In other words, one year of work yields eight semester hours in each course.

It will be noted that the same fundamental courses are prescribed that are required in any college or university, namely, 12 quarter hours (8 semester hours) of general chemistry, 8 quarter hours of qualitative analysis, 8 quarter hours of quantitative analysis, 12 quarter hours of organic chemistry, and 8 quarter hours of physical chemistry. In addition 4 quarter hours of advanced organic, advanced quantitative, or physiological chemistry (in 1932) are offered for those who desire it. This is not unusual for a college chemistry curriculum, but the authors are acquainted with the conditions in a number of Teachers' Colleges which are prevented from offering this number and variety of courses due to various curricular difficulties, and it is especially for their interest that the following schedule is presented.

Course for Chemistry Majors

Fall Term	*Winter Term*	*Spring Term*
	FIRST YEAR	
General Chemistry	General Chemistry	General Chemistry
College Algebra	College Algebra	Trigonometry
German	German	German
Rhetoric	Rhetoric	Rhetoric
Physical Education	Physical Education	Physical Education
	SECOND YEAR	
Qualitative Analysis	Qualitative Analysis	
	Quantitative Analysis	Quantitative Analysis
History or Economics	History or Economics	History or Economics
Health Education	Biology, Geography, or Geology	Biology, Geography, or Geology
Literature		Literature
	THIRD YEAR	
Organic Chemistry	Organic Chemistry	Organic Chemistry
Analytics	Analytics	Elective
Physics	Physics	Physics
Education (Psychology)	Education	Education

FOURTH YEAR

Education	Education	Education
Practice Teaching	Practice Teaching	Practice Teaching
Calculus	Calculus	Calculus
Elective	Physical Chemistry	Physical Chemistry

A summary of the four-year course shows in brief:

Chemistry	48 quarter hours
Mathematics	32 quarter hours
Education	24 quarter hours
Practice Teaching	12 quarter hours
English and Rhetoric	20 quarter hours
German	12 quarter hours
Physics	12 quarter hours
Social Science	12 quarter hours
Earth Science or Biology	8 quarter hours
Health Education	4 quarter hours
Electives	8 quarter hours
Total	192 hours plus required physical education

To accommodate a number of students from this section of the state who take their first two years of pre-medical work here, the department suggests and offers the following schedule:

First Year	General Chemistry	3 terms
	Qualitative Analysis	Summer Term (12 weeks, double time)
Second Year	Organic Chemistry	2 terms (Fall and Winter)
	Physiological Chemistry	2 terms (Spring and First Summer Session)

This gives them 36 quarter hours of chemistry (more than is required by most medical schools) and at the same time by allowing completion at the end of the first half of the summer quarter the student has sufficient time to obtain full transfer of credits and entrance into a medical school in the fall of his third year.

Discussion

The four-year schedule as presented includes all courses necessary for a bachelor of education degree from this institution with a major in chemistry and a minor in mathematics. Undoubtedly, the most distinctive feature of this schedule is the absence of electives. Only two unprescribed subjects are open in the whole four years, and physiological chemistry is urged for one of them if all other requirements have been met. Part of the scarcity of electives is due to the fact that although nine terms of work constitute a major, this department feels the necessity of, and dictates, the

twelve terms as specified for a full major in chemistry. In place of the ten electives that would remain if only the minimum requirements for a degree were met, this department chooses to prescribe that eight of the ten electives shall be used as follows: three extra courses in chemistry, two extra courses in mathematics, and three terms of physics.

The fact that a student majoring in chemistry must also complete nine terms, or a major, in education necessarily reduces the number of electives in his course. In the training of a teacher, however, this is quite important, especially since three of these terms of education are practice teaching. At least two of these terms of practice must be done in teaching a high-school chemistry class under the supervision of a qualified critic.

It is a well-known fact that many teachers, especially those lacking in experience, are forced to accept positions in fields far removed from their major. To meet this possibility, the schedule presents sufficient diversity so that by following the common practice of attending a six-weeks' summer session a minor (24 quarter hours) may be had in any of the following fields: physics, history, or literature.

Another feature of the course which may attract attention in educational circles is the absence of methods courses in science teaching. The authors do not wish to offer here a brief for or against science methods courses, but they feel that the student of ordinary observative powers will have obtained sufficient suggestions in methods of presenting the science during his four years of chemistry under the various instructors in the department, which, with the advice and guidance offered him in his actual practice teaching, will qualify him as a teacher. It might be added that experience in handling apparatus and supplies and in the preparation of solutions and demonstration materials is obtained through the practice of the department in choosing its majors for stockroom assistants (with pay).

Another omission—that of courses in food and agricultural chemistry—is readily explained by the fact that this school does not offer more than a minor in home economics and agriculture. Even so, the attitude of the department is that a thorough foundation in the science with the application of its principles would go far toward supplying the requisites of such a course, and without the foundation such courses would fail in their aims.

The definite trend in the requirements for high-school teachers, and one which students themselves realize if they wish to rise to the ranks of those in demand, is for advanced degrees in their major field. This curriculum supplies the prerequisites for that possibility, and majors in this department have been accepted for graduate study leading to the M.S. and Ph.D. degrees.

With these various possibilities, the authors feel that a desirable course has been arranged for those who are interested in the teaching of chemistry.

Minors are of correlative value, but are also of sufficient diversity to enhance the possibility of obtaining a position. And, finally, to answer the demands of the constantly rising qualifications placed upon new teachers, or for those who may have an adaptability for research work, the curriculum presented is of sufficient completeness and intensity to qualify as an acceptable preliminary for work toward an advanced degree in a university.

The National Research Council. When, in 1917, the United States entered into the World War, it was necessary to mobilize every agency in the nation for its defense. As no war in these modern times can be brought to a successful conclusion without making the greatest use of the scientific and technical institutions of a country, President Wilson requested the National Academy of Sciences, which had been duly constituted by Congress the national center for scientific effort, to organize an emergency body to centralize research activities for defense purposes.

The National Research Council was therefore established by the Academy. Its assistance in the years of emergency proved so valuable as to demonstrate its capacity for permanent service as a center of national effort. Accordingly, President Wilson requested the National Academy to arrange for a permanent organization for the Research Council, under the authority given by the charter of the Academy.

Soon after forming this permanent organization, it became necessary to arrange if possible for a permanent home for the Academy and its agent, the Council. After careful consideration of the needs of the two bodies, the Carnegie Corporation of New York gave the money for the erection of a building. . . . .

Thus constituted, the Council is a central administrative organization for the scientific and technical research institutions of the country. It has authority to administer funds granted for research. It has grants for research fellowships, and for publication purposes. Large endowments come from the Rockefeller Foundation and the Laura Spelman Rockefeller Memorial; from the General Education Fund and the International Education Board; and from The Chemical Foundation. . . . .The total annual receipts from all sources are over a million dollars.

The Council is active in the publication field, although much of the results of its committee research are published in the scientific and technical journals, or in the publications of various societies. . . . .

The details of research projects are in charge of numerous committees of the Council, which does not itself engage directly in research. These committees are made up of the most prominent investigators in the several fields, men who know what there is to be done, what has already been accomplished, what is being done at present, and who is doing it. The Council is in the closest relation to the faculties of the various scientific and technical schools, the research workers in the scientific laboratories of the United States Government, and with those men engaged in investigation for large corporations or for technical societies and trade associations. For the work of coördination and classification of the activities of these committees, the Council has organized divisions for each science, the duty of these divisions being to arrange for meetings of these committees, to keep in touch with the problems which they are investigating, and to register and collect all papers prepared for presentation at these meetings or elsewhere. . . . .

Following the example of the United States, other countries have organized similar research councils, and these have joined in an international organization for mutual help and advice. All of these will serve to foster the spirit of research, without which little economic progress can be made.—*Ind. Bull. of Arthur D. Little, Inc.*

A DEMONSTRATION WORKING MODEL OF THE FRASCH PROCESS FOR MINING SULFUR

SAMUEL H. LEBOWITZ, TEXTILE HIGH SCHOOL, NEW YORK CITY

This paper describes the construction and operation of a demonstration working model of the Frasch Process for mining sulfur. The model may be built, without any special skill, of apparatus ordinarily available in the secondary-school laboratory. It may be satisfactorily operated without danger from extremely high temperatures or pressures.

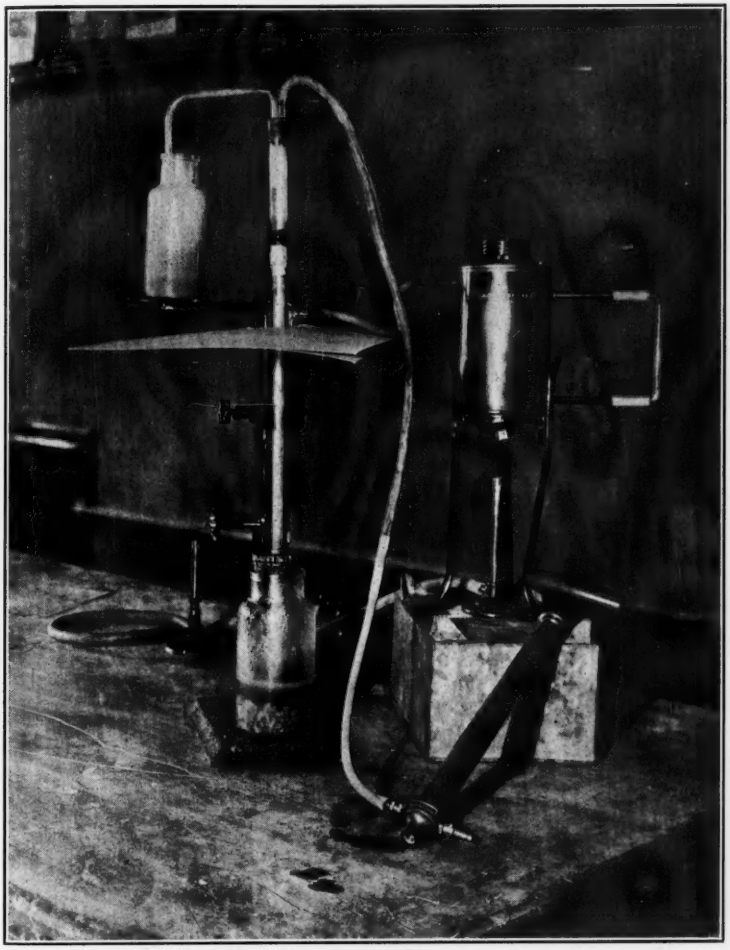
. . . . . .

Need for Demonstrations of This Type

Any chemistry teacher of experience is familiar with the difficulties of the average pupil in visualizing industrial apparatus and machinery. Diagrams, as a rule, fail to convey the necessary three-dimensional impression because of the pupil's lack of training in their interpretation. Due to this failure to understand the construction of the devices, it is almost impossible to make clear to such a pupil the operations that are carried out in them. In many cases, however, it is possible to build models which duplicate the constructional features of the commercial devices, but are, unfortunately, inoperative. Such models, much as they may help for some purposes, are, however, far less desirable than others which not only indicate the construction of the industrial machinery, but which also, in small-scale operation, duplicate the processes to be demonstrated. It is the purpose of this paper to describe a demonstration of the latter type. The model described has the further advantage that it may readily be constructed of materials available in the laboratories of the average secondary school.

Theoretical Considerations That Governed the Design

The Frasch Process is well known and is considered of sufficient importance to be mentioned and described in many high-school texts on general chemistry. Without going into a detailed discussion, it may be seen that one of the essential steps is the melting of sulfur undergound by superheated water at a temperature of 168 degrees Centigrade and a correspondingly high pressure. It is apparent that the use of the pressure necessary to superheat water to this temperature would preclude the employment of glass apparatus, and would necessitate the construction of devices of great physical strength. In order to avoid the danger accompanying such high temperatures and pressures, it was thought advisable to substitute for the sulfur a material which resembled it sufficiently to give a satisfactory impression, but which would melt at a much lower temperature. The material finally chosen as meeting these requirements was paraffin, which was dyed to a suitable yellow color by the admixture of some strongly colored yellow wax candles. Oil-soluble dyes of the type used in preparing these candles would, if available, serve to color ordinary paraffin for this purpose.

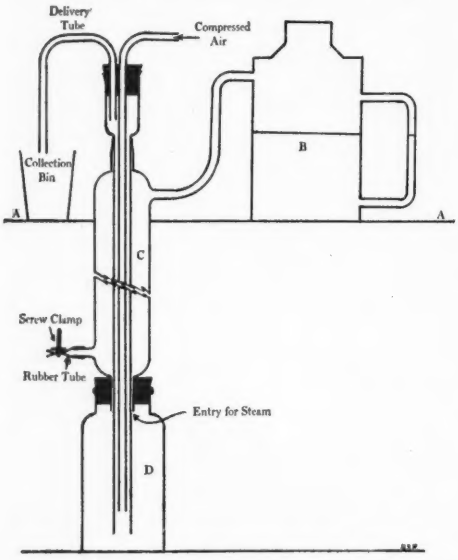


PHOTOGRAPH OF MODEL DESCRIBED

It was found that glass tubing of sufficiently large diameter for the outermost of the three casings characteristic of the Frasch Process was not to be had in either of the laboratories with which the author is connected, nor was it believed to be readily available in any ordinary secondary school laboratory. A survey of the apparatus on hand disclosed the fact that a Liebig condenser might easily be adapted for use in the model apparatus.

Construction of the Apparatus

The accompanying photograph and diagram show the apparatus as finally developed and used by the author. A wide-mouthed bottle (*D*) filled with lumps of yellow paraffin serves to represent the underground deposits of sulfur. The lower rubber connection is removed from a Liebig condenser of the separable type (*C*). The cork of the wide-mouthed bottle is bored to fit the lower end of the condenser water jacket. Both the inner tube and water jacket extend into the wide-mouthed bottle. A third tube, to carry compressed air, is then introduced, as shown, through the center of the condenser. This tube passes through a two-hole rubber stopper at the upper end of the condenser. A delivery tube is provided through the second hole of the stopper to conduct the materials raised to a second wide-mouthed bottle, representing the storage bin. The upper inlet of the water jacket is connected to a source of steam supply, which is, in this case, a copper boiler; and the lower outlet tube is closed off by means of rubber tubing and a screw clamp as shown.



AA—GROUND LINE; *B*—BOILER; *C*—CONDENSER; *D*—BOTTLE CONTAINING WAX (REPRESENTING SULFUR)

Operation of the Demonstration

Steam is introduced into the outermost tube, *i. e.*, the water jacket, of the condenser and passes into the wide-mouthed bottle through the narrow space between the condenser jacket and the inner condenser tube. The paraffin melts gradually and accumulates at the bottom of the bottle. When a sufficient amount has melted, the compressed air is turned on. This may be done by blowing through the central tube or by the use of some other source of air under pressure. The paraffin(sulfur)–water–air mixture then rises through the intermediate tube and passes by way of the delivery tube to the storage bin. Pebbles added to the paraffin will not be affected by the steam, and will therefore demonstrate the effectiveness of the process in purifying the

sulfur and will help to explain the great purity of the substance when mined commercially in this way. The apparatus may be cleaned by continuing the passage of steam for a short time after the paraffin has been raised and the compressed air turned off.

Conclusion

The demonstration as described duplicates all the essential features of the Frasch Process, including the three concentric tubes, the melting of the material underground, the elimination of impurities because of their higher melting points and densities, and the forcing of the material to the surface by the action of the compressed air to produce a lighter product which may be lifted by the combined steam and air pressure.

Acknowledgments

The author wishes to acknowledge the assistance of Mr. Joseph Glanz of the Yeshiva College, New York City, in preparing the original model; and of Mr. Robert Remington of the Textile High School in drawing the accompanying diagram.

Alchemy. In the ancient city of Bagdad dwelt a certain wise man called Hajai, whose wisdom was greater than that given to most men. It was the custom for all those going on a caravan to seek him out for advice and counsel regarding their journeys and their fortunes.

A certain youth, Melthan, came to him saying, "Oh, Wise One, I am about to go out to seek my fortune. What would you bid me do if I am to acquire riches?"

And Hajai answered him, saying, "Keep thou a record of all thou doest and wealth will be given thee."

The youth went forth. Years later, Melthan returned to Bagdad with a princely caravan and found Hajai sitting at the gate.

"How now, O Youth?" Hajai hailed him. "I see thou hast kept my counsel."

"Ay," the youth replied. "Riches have become mine but I have not happiness."

"Let me see the record," said Hajai.

The youth handed him the scroll wherein the record was kept, showing fairly the profits and the losses and all business ventured.

"And is this all?" asked Hajai.

"That is all," said the youth.

"Ah," said Hajai, "thou hast kept only the inventories of thy business. Where are the names of thy friends, sports, secret thoughts and of pleasant places?"

"What have these to do with gold?" said the youth.

"They *are* the *gold*," said Hajai, "and time is the alchemist."—*Selected* via *The Hexagon of Alpha Chi Sigma*

Activity back of a very small idea will produce more than inactivity and the planning of genius.—JAMES A. WORSHAM

ELECTRODIALYSIS WITH SIMPLE APPARATUS*

ARTHUR ISAAC KENDALL AND ERICH GEBAUER-FUELNEGG, NORTHWESTERN UNIVERSITY MEDICAL SCHOOL, CHICAGO, ILLINOIS

A brief historical account of the invention of electrodialysis is given. It is pointed out that even though a considerable number of scientists have applied the method, in research as well as in industry, and while reviews of the subject have been published, the process is still one of the group of the "neglected methods."

The advantages, however, are in many instances so unequivocal that it should have a very definite place among the methods of organic chemistry. The principles involved in the process of electrodialysis make its study both interesting and instructive (a number of cases have been reported which offered results unobtainable by any other method).

The fact that electrodialysis remains among the "neglected methods" may be accounted for as follows: (1) it is ordinarily given inadequate treatment in textbooks; (2) its advantages and applicability are not generally recognized; (3) simple and efficient types of electrodialyzers for general laboratory use are scarce.

Two machines which worked satisfactorily in the writer's laboratory are described and photographs are included. One machine is used for experiments on a small scale, and the other for larger volumes. In both cases, the apparatus can be easily set up from glassware that is readily obtainable.

. . . . . .

That process to which the term "electrodialysis" is applied, is a comparatively recent invention, frequently credited to W. Pauly. In a recent review on this subject (1927), Charles Dhere claimed priority as an independent discoverer, basing his claim on papers published around 1909 (*1*). He admitted, however, that two American scientists (*2*) had already used the fundamental principle in 1903, but had failed to emphasize the general applicability and value of the method. A few months later, J. Reitstoetter (*3*) amplified the bibliographical data of the French author, making special reference to work which had been done in the industrial field which had not been mentioned in the Dhere report. Thus it appears that as early as 1896, D. Winkler, in the British Patent Number 5749, described a method for the purification of albumoses and protein degradation products by means of the electric current. Credit has also been given to Count Botho Schwerin, the lawyer-inventor of Germany, for extensive work in connection with the developments of the electrodialytic process. His first patent [D.R.P. 168,853], granted in 1900, was for a method of purification of substances of cellular origin and proteins by means of the electric current. In it is found a precise explanation of the process and the principles in-

* Delivered before the Division of Chemical Education at the 81st meeting of the A. C. S. at Indianapolis, Indiana, April 1, 1931.

volved, which are very properly described as a combination of two simultaneous parallel processes, namely the electrolysis of the dissociating substances and of the electroendosmosis of the substances which are not dissociated. It may be interesting to recall here another definition of the electrodialytic process given by H. Freundlich and L. F. Loeb (*4*) in 1924, according to which electrodialysis is a combination of dialysis and electrolysis: the separation of electrolytes from a colloidal system through semipermeable membranes.

Even though a review of the literature shows quite clearly that a considerable number of scientists have applied electrodialysis both in researches and in industry, the process is still one of the group of the "neglected methods" if compared with the wide field of possible application. The advantages, however, are in many instances so unequivocal that it should have a very definite place among the methods of science, also the principles involved make the study of the electrodialytic process both interesting and instructive.

There appear to be several reasons for electrodialysis being a "neglected method," a few instances may be cited. 1. In the first place, a survey of a number of textbooks on various branches of chemistry shows that only a few (*5*) give the subject adequate attention. 2. The advantages and applicability of the method have not been generally recognized. 3. Even though quite a few machines for special electrodialytic purposes are described by various authors, there seems to be no simple and efficient type of electrodialyzer for general laboratory use.

The first objection cited above can be overcome only by a complete description of the method in textbooks of wide circulation. The second point might be somewhat neutralized by enumerating and re-emphasizing the broad variety of possible applications, while the lack of a suitable electrodialytic outfit might be overcome by describing two simple types of apparatus which have been used to best advantage in our laboratory.

Without attempting a complete enumeration of the fields in which electrodialysis has been successfully used, since this has been so well done in the two reviews which have already been referred to, the following should be mentioned.

I. *In the chemistry of high polymers, comprising proteins, cellulose and its esters, starch and similar substances.*

This type of compound is especially suitable for electrodialytic purification on account of the high molecular weight of the substances which comprise it. In virtue of this weight, they encounter difficulties in passing through semi-permeable membranes, while their impurities, such as inorganic electrolytes, organic crystalloids, and substances of small molecular weight, migrate through the diaphragm, especially when under the influence of an electric potential. It is, therefore, quite natural that the

early work centered around this type of substance. The results obtained were very satisfactory and as a rule superior to other methods of purification. The last traces of inorganic impurities of gelatin and nitrocellulose can also be eliminated only by electrodialysis.

II. *Degradation products and carbohydrates of smaller molecular weight.* The separation of protein hydrolysates into a primarily basic, a chiefly acid, and a third fraction which has neither a pronounced acid nor alkaline character, has been achieved by electrodialysis in a three-chamber apparatus. The importance of maintaining a definite pH in order to obtain certain effects was also brought out in the study of these substances. By this method, for example, histidine can be separated from arginine and lysine (*6*). The isolation of glycocholic acid (*7*) from bile extract will serve as another example.

The separation of physiologically active bases from proteins or degradation products was recently accomplished when protein or gelatin solutions containing histamine or choline were successfully electrodialyzed and the base recovered (*8*).

III. *The successful purification of alkaloids* by this method might conceivably lead to preparations of standardized purity for pharmaceutical purposes (*9*).

IV. *Interesting results were obtained with enzymes:* amylase, which after prolonged dialysis is still active toward starch, was found to have lost its activity when electrodialyzed (*10*). When electrolytes are again added, however, its power of fermentation is said to be restored. If these experiments should prove to be duplicable, a very interesting aspect of enzyme action would have been brought out by means of electrodialysis.

V. *In the field of antibodies and hormones,* interesting findings have been made which may prove to be of general importance. Certain antitoxins, as that of diphtheria serum, can be concentrated and separated by electrodialysis under proper conditions (*11*). In this connection, the isolation of immunizing substances in general should be mentioned as of major importance (*12*). Successful work has also been done in the field of insulin separation (*13*).

In the following paragraphs two machines will be described which work rapidly and efficiently. They have been designed with the purpose of obtaining an appliance which can be rapidly and easily set up in every laboratory, and which should enable more extensive work to be done in this field.

For small samples and preliminary experiments, the three-compartment vessel as shown in Figure 1 was used. It is made of a short piece of glass tubing of any desired width [the one illustrated being $3'' \times 1''$]. This tube is provided with a fair-sized hole blown into the middle of the wall. Two other glass tubes of desired length, and either slightly larger or smaller than the one just described, are also provided with a hole and are used as

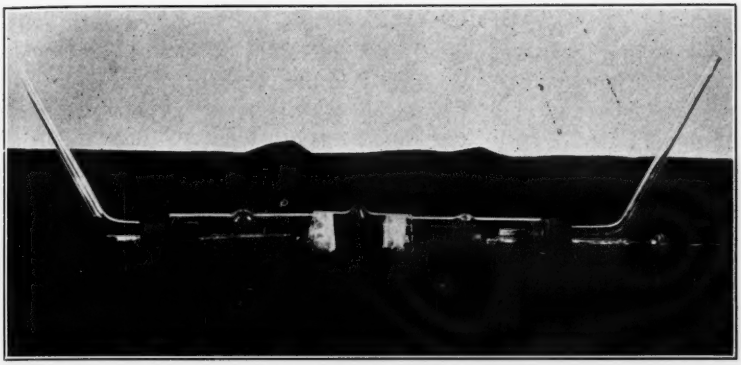


FIGURE 1

the two outer compartments. In place of membranes, parchment paper is folded over one opening of each of the tubings. If the middle tube is of slightly wider diameter, they are inserted.* If smaller, the end tubes are slipped over the middle piece after the parchment is in place. A rubber band and collodion are used in adjusting the apparatus and making it

* A piece of rubber tubing can also be used as a middle cell. If desired the apparatus can be made in U shape to facilitate cooling.

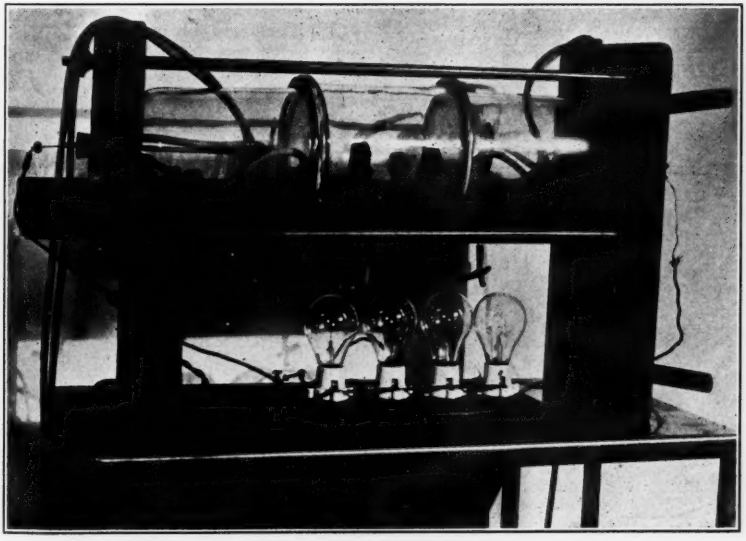


FIGURE 2A

tight. This is clearly shown in the photograph. The electrodes, preferably platinum wire, are inserted each through a two-hole stopper which also holds glass tubings through which the contents of the outer cells may be siphoned away. This apparatus may be varied in size for any desired purpose. Direct current and possibly a lamp resistance will be all the additional equipment necessary for experiments on a small scale.

The second apparatus, which is shown in Figure 2, *A* and *B*, is designed for the electrodialysis of larger volumes. Selections from the stock of glassware of a laboratory supply house* were drawn upon for the apparatus as finally made. The two outer cells were made of bell jars in the walls of which two holes were bored opposite each other. For the middle cell, a glass jar with a ground glass cover of the same diameter as the base of the bell jar was chosen. The bottom of this jar was cut out to provide a glass cylinder with two open sides.** A sufficient amount of the bottom was left to be used as a flange. Between the three compartments, parchment membranes were placed. They were held together by a simple cradle-like wooden stand. A sliding head block which may be forced against the glass apparatus by means of four bolts holds the parts firmly in position. The electrodes were inserted through the tubulatures of the bell jars. A thin platinum disk may be used for the anode chamber; inexpensive nickel electrodes proved satisfactory as cathodes.

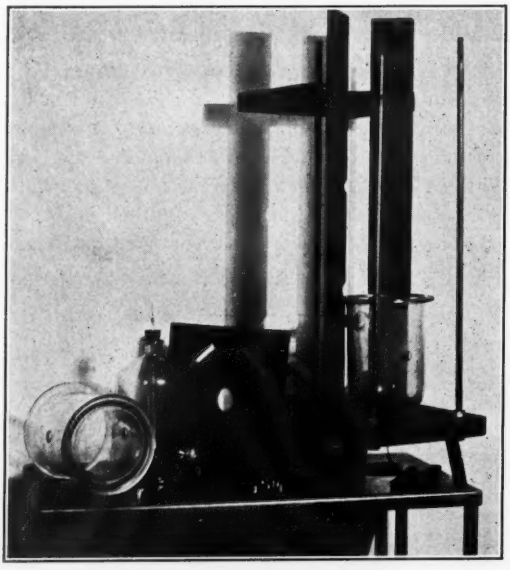


FIGURE 2*B*

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(*1*) DHERE, *Kolloid-Z.*, **41**, 243, 315 (1927).
(*2*) MORSE AND PIERCE, *Z. physik. Chem.*, **45**, 606 (1903).

* The glass parts can now be supplied by E. Sargent & Co., Chicago, Ill.

** A rubber ring between the cells proved advantageous.

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(4) FREUNDLICH AND LOEB, *Biochem. Z.*, **150,** 522 (1924).
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Sulfur in Soap. Ordinary sulfur frequently produces a skin irritation that precludes its use in soap and reduces its effectiveness as a skin remedy. A new type of sulfur, the by-product of the thylox process of gas purification, seems to be free from these undesirable properties; in fact, it seems to possess unusual qualities that commend it to the manufacturer of insecticides, fungicides, and soaps.

Thylox sulfur is of a colloidal nature, an exceedingly fine grade of pure sulfur derived from the hydrogen sulfide in coal gas.

The idea that it might be advantageously used in soap was hit upon during a toxicological investigation of the thylox purification process by the Koppers Research Corporation. It was noticed by the investigator, Dr. Emery R. Hayhurst, of Ohio State University, that some of the workmen were using the by-product sulfur as a hand cleanser. When questioned, they claimed that it had excellent cleansing qualities, and that it seemed to be beneficial to the skin of those who were exposed to salt solutions encountered in the processes. The Koppers Research Corporation thereupon began to experiment with the sulfur as a detergent combined with a soap base. Once the soap was made, Dr. Hayhurst investigated its uses and effects. From his preliminary study he concluded that the soap is unusually bland in its effects on the normal skin, including the scalp. He further found that the soap has prompt, beneficial, and even curative effects on the simpler forms of skin diseases, and that it has pronounced preventive and curative properties in certain occupational dermatoses, such as platers' rashes, "machinists' boils," and the like.

While the thylox sulfur may be used as a paste, ointment, or powder, its successful use as a detergent in soap is noteworthy and commands particular attention as a preventive of occupational dermatitis.—*Tech. Review*

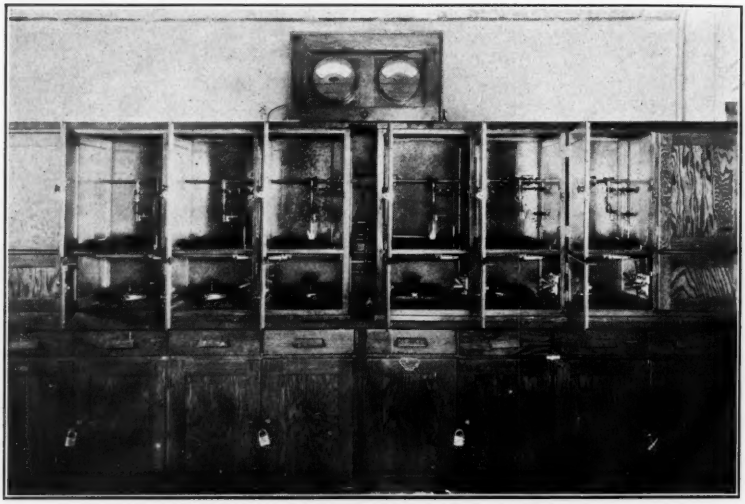
Nitrogen Tri-Iodide. The composition of nitrogen iodide appears to vary according to the method of preparation, the ordinary substance being regarded as $NI_3 \cdot NH_3$ or NH_2I. In the December issue of the *Journal of the Chemical Society*, Cremer and Duncan describe some experiments on the action of dry ammonia on iodine bromide or, more conveniently, a polyhalide such as $KIBr_2$, which dissociates into potassium bromide and iodine bromide. In these reactions NI_3 is formed. The more stable dibromoiodides, such as those of tetramethylammonium and trimethylsulfonium, do not react in this way, but form additive compounds with ammonia. The iodide of nitrogen was obtained by washing gas on the polyhalide, and was a black explosive powder.— *Nature*

AN INEXPENSIVE STIRRING DEVICE FOR THE ANALYTICAL LABORATORY*

HARVEY V. MOYER, THE OHIO STATE UNIVERSITY, COLUMBUS, OHIO

A stirring device, which presents certain features which may be of some general interest, has been installed in the analytical laboratory at The Ohio State University. The stirrers were designed to equip a series of cabinets for the rotating electrode method for the determination of copper.

Front-wheel bicycle hubs were used for bearings. These are made with ball bearings and will operate for months with a single greasing. Nearly all large hardware stores have the hubs in stock and sell them for approximately seventy-five cents each.



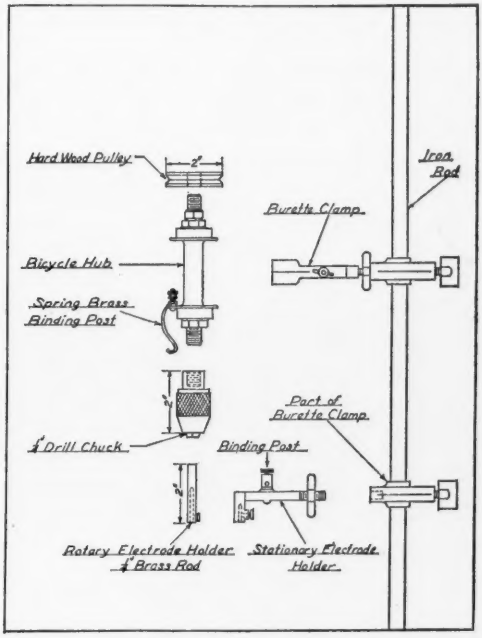
STIRRERS IN THE ELECTROLYTIC CABINETS

The accompanying photograph shows the stirrers in the electrolytic cabinets. A horizontal shaft which is mounted on three hubs for bearings serves to carry the power to each compartment. The cabinets are built in sections containing four compartments. Two of these sections are operated by a single $^1/_4$ h.p. motor which is mounted on a shelf behind the cabinet. The stirring device in each compartment consists of a front bicycle hub with a 2-inch hardwood pulley screwed on one end of the axle and a small hand-drill chuck screwed on the other end. The accompanying drawings show the simple method of construction. The drill chucks were bought at a local "ten-cent" store and, although not perfectly made, serve

* Delivered before the Division of Chemical Education at the 81st meeting of the A. C. S. at Indianapolis, Indiana, March 31, 1931.

very well for this purpose. The upper part of the chuck was cut off and a hole was drilled into the shaft as shown in the drawing. The material for the complete stirrer costs approximately one dollar.

Special electrode holders were made for the determination of copper. Their construction is obvious from the drawings and the photograph. The electrodes are insulated from each other by means of a strip of rubber wrapped around the hub of the stirrer. Electrical connection to the rotating electrode is made by means of a binding post fastened to the hub through one of the holes in the hub which were made for the bicycle spokes. A piece of spring brass makes contact with the rotating shaft of the drill chuck.



DETAILS OF CONSTRUCTION

The cabinets were designed by Professor C. W. Foulk of this laboratory. The rheostat and the switches are placed in the lower compartment of each unit where they are protected from the fumes of the solutions which are being electrolyzed. The cabinets are wired so that a single voltmeter and ammeter can be used for all eight compartments.

The use of the cabinets has not been confined to the determination of copper. The device has proved very useful in many other gravimetric determinations since it has been possible to substitute periods of stirring for long digestions. It has been found that a special equipment for stirring has decreased considerably the time required to complete a given set of exercises in analysis. In this laboratory 16 stirrers are used by approximately 150 students in quantitative analysis.

Every man is really two men, the man he is and the man he wants to be.—SAMUEL M. CROTHERS

Correspondence

THE REFINING OF MESOTHORIUM—CORRECTION

DEAR EDITOR:

In my article "The Refining of Mesothorium" in the July issue of the JOURNAL, there is a mistake in Figure 1, page 1272. Under the column marked *Half-life Period* the value 10.6 hr. should be inserted directly opposite Th-B; the 60 min. should be opposite Th-C.

HERMAN SCHLUNDT

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BERNARD PALISSY, SIXTEENTH-CENTURY SCIENTIST—CORRECTION

DEAR EDITOR:

A criticism of my article "Bernard Palissy, Sixteenth-Century Scientist," pages 1044–59 of the June, 1931, issue of the JOURNAL OF CHEMICAL EDUCATION, has come to me and it is one for which I alone am to blame; *i.e.*, the omission of the bibliography. Of course I have it, every reference and quotation, page and line, but for some reason, entirely unfounded, I did not associate bibliography with this short paper. For those who may be interested, I am herewith submitting it.

The accompanying photograph is of the statue of Bernard Palissy in the churchyard of St. Germain-des-Prés, Paris. This photograph arrived too late to be published with the article itself.

MARY LOUISE FOSTER

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THE CONCEPT OF THE POUND-MOLECULAR-VOLUME—CORRECTION

DEAR EDITOR:

In an article dealing with "The Concept of the Pound-Molecular-Volume" published in the JOURNAL OF CHEMICAL EDUCATION, July, **1930,** page 1659, the statement is made that the relationship that the ounce molecular volume of a gas is equal to 22.4 cubic feet was discovered by Dr. T. W. Richards.

I wish to call attention to the fact that credit for the discovery of this relationship should be given to Dr. Joseph W. Richards, one-time professor of metallurgy at Lehigh University. In his book entitled "Metallurgical Calculations" (McGraw-Hill Company, **1906**) this relationship is set forth on pages 3 and 4.

O. F. STAFFORD

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NOTE ON "AN INEXPENSIVE BURET SUPPORT"

The type of buret support shown in Figure 3 of Pagel's article [J. CHEM. EDUC., **8,** 161 (Jan., 1931)] can be easily modified to give the advantage of a constant level buret.

To do this the filling tube is drawn out to a tapering capillary long enough to extend to the zero point of the buret and with an opening of about 1 mm. in diameter, carefully fire-polished. This filling tube is then adjusted

so that the excess solution drawn into the buret will be siphoned back into the bottle and thus give a zero reading on the buret. Occasional readjustment may be necessary, but it is easily accomplished.

The use of the constant level type of buret has proved time saving and satisfactory in this laboratory.

ED. F. DEGERING

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Chemists Deal with Merest Traces in Analyzing Soils. Department chemists find that some problems of soil analysis challenge the accuracy of the most painstaking of scientific workers. Many constituents of agricultural soils occur in such minute quantities, say the soil chemists, that in ordinary analytical work they would be disposed of by saying there was a "trace." The soil chemist learns to deal in traces.

W. O. Robinson, of soil investigations, Bureau of Chemistry and Soils, illustrates this fact in a discussion of the methods now followed in the bureau.

"The phosphoric acid determination," he says, " is a stumbling block to the average analyst. A concrete idea of the importance of accuracy in soil analysis may be had by calculating the increase of phosphoric acid and lime in the soil, as the result of adding a liberal dressing of these fertilizers. An application of 200 pounds of phosphoric acid to the acre will raise the percentage of phosphoric acid in the surface soil by only about one-one-hundredth of 1 per cent."

The upper 6 inches of an acre of soil weighs approximately 1,750,000 pounds, the chemists have discovered. In one of the notable achievements of soil science it was found that certain previously unproductive soils in Florida would grow excellent crops of tomatoes if fertilized with only a few pounds per acre of manganese compounds. In certain tobacco soils the addition of a few pounds of magnesium per acre has made differences in production that have fairly astounded the growers. In dealing with such infinitesimal traces of chemical substances, chemists are forced to use the purest reagents available, and to give the most scrupulous attention to their methods. In some processes it is necessary to use only platinum vessels.—*The Official Record of the U. S. Dept. Agriculture*

Marine Animals Analyzed to Learn Life Needs. Zoölogists studying the life of the sea are now calling chemists in to their aid, Dr. Paul S. Galtsoff of the U. S. Bureau of Fisheries told the American Association for the Advancement of Science at its recent meeting in Pasadena. Such studies have become necessary because of discoveries of the great fluctuations, even from day to day, in the concentration of necessary chemical elements in sea water, and also because of the new knowledge of the great importance of some elements, like copper and manganese, present in only the minutest amounts.

Oysters, for example, were discovered by Dr. Galtsoff to require a trace of copper, but no more than a trace, before they abandon the wandering habits of their youth and settle down on the bottom to grow fat and profitable for oystermen. There is practically no copper in pure sea water but there is a little in river water, so that oyster beds are almost invariably found near the mouths of rivers.

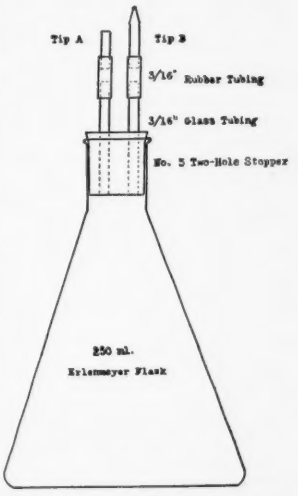
Another example of the importance of a chemical-biological understanding of the life of the sea cited by Dr. Galtsoff was the work of sea animals, particularly the microscopic forms, in depositing lime beds that eventually become limestone. The annual deposit of limy material laid down by living animals in the sea amounts to 1,400,000,000 tons.—*Science Service*

Abstracts

APPARATUS, LABORATORY PRACTICE, AND DEMONSTRATIONS

A New Insulator for the Hot Water Bottle. C. W. EDDY. *Chem. Analyst,* **20,** 20 (May, 1931).—A good grade of smoked sheet rubber $^1/_8$ to $^1/_4$ inch thick is soaked in some rubber solvent (*e. g.*, CCl_4, benzine, or gasoline) until it becomes soft and shows signs of dissolving. The strip which should have been cut about $^1/_8$ inch longer than the circumference of the neck is then placed around the neck of the flask and worked until the seam is no longer visible. The stickiness originally present soon disappears, or can be removed by dusting with soapstone. If the flask breaks the rubber can be slipped off and put on the neck of the new flask. Smoked sheet, being corrugated, presents a rougher surface and aids in securing a good hold. It is a much better insulator than vulcanized rubber. D. C. L.

Apparatus for Continuous Leaching with Suction. J. F. FUDGE. *Ind. Eng. Chem., Anal. Ed.,* **3,** 114 (Jan., 1931).—In many cases leaching proceeds very slowly, so that much time is required for leaching and washing. The diagram shows a very simple arrangement. The apparatus is inverted after filling and so supported that the ends of both tips are within and below the edge of the crucible. The rubber tubing enables a slight adjustment of the height of the glass tips. Tip *B* is drawn to a small hole so as to prevent splashing. Tip *B* should be at least a quarter inch longer than *A*. D. C. L.



A Rapid and Efficient Method for Cleaning Distillation Flasks. E. C. NIELSEN. *Chem. Analyst,* **20,** 22 (May, 1931).—Oil and other distillation flasks may be readily cleaned by introducing a small stream of air through a metal pipe while heating the flask to redness with a burner. The stream of air accelerates the burning and carries away the gases, leaving the flask dry. Pyrex flasks may be cleaned several times a day for six months or more before they are ready to be discarded. This method applies to the removal of all combustible materials. D. C. L.

Methods of Breaking Emulsions Formed during Process of Ether Extractions. L. HART. *Chem. Analyst,* **20,** 14 (Jan., 1931).—Emulsions often form in extraction of soaps, cosmetic creams and lotions, oils, insecticides, etc. Separation may be promoted in several ways. (1) Carefully run 2–3 cc. conc. NaOH down the side of the separatory funnel. (2) Add 2–5 cc. alcohol down the side of the funnel and allow a drop to fall on top of the liquid. (3) Sift a gram or two of NaCl into the mixture. (4) Place unstoppered funnel into the ring of a steam-bath. A short time may be necessary to start separation. Do not swirl funnel. D. C. L.

The Preparation and Properties of Highly Purified Oleic Acid. J. H. SKELLON. *Chem. & Ind.,* **50,** 131T–134T (Apr. 10, 1931).—Two methods are outlined for separating oleic acid from olive oil. Determinations were made of the refractive index, iodine value, setting and melting points. E. R. W.

TEACHING OBJECTIVES, METHODS, AND SUGGESTIONS

Shall We Plan Each Science Lesson? *Sci. Classroom,* **10,** 1 (Apr., 1931).—Some basic principles that it is well to keep in mind in regard to planning lessons are: (1) the teacher should budget the time in accordance with the requirements of the course of study, (2) the budget plan of periods necessitates that a well-conceived plan for each period be adopted, (3) the experience of the teacher and his command of the subject matter will determine the completeness with which he needs to fill in the outline, (4)

emergency situations arising in the classroom must be met open-mindedly, (5) the type of lesson determines the exact type of plan to be used. Suggestions are offered for use in planning a series of lessons on one topic, as: (1) a preliminary or exploratory lesson for the determination of the degree of familiarity of the students with the material, (2) a lesson in which the new concepts are presented, (3) a lesson dealing with applications of the principles, (4) a lesson for pupil reports and discussions, and (5) a lesson for review and drill. H. T. B.

The "Board of Inquiry" versus the "Lecture-Recitation" Method of Education. E. BENNETT. *J. Eng. Educ.*, **21**, 512–6 (Mar., 1931).—The lecture-recitation class is the customary method of aiding students to grasp any branch of organized knowledge, as calculus, physics, etc. In this method, one or more periods per week are used by the instructor in lecturing his entire group of students which may be 50 to 300. The recitation period groups are limited to 18–24 students and occupy the remaining number of periods per week. Approximately 35 minutes of each 50-minute recitation period remain for discussion after the necessary duties of the instructor are performed. This means that each student may have the floor about 2 minutes at the most. One criticism often advanced concerning a typical engineer is that he is unable to make good off-hand oral presentations of his views.

A boy who chooses engineering as a profession shows a predisposition to deal with the not easily debatable principles of the physical sciences, and his study of them confirms the tendency. With this in mind, it is proposed to try a board of inquiry method, in which the instructor's section of 18–24 students is still further subdivided into groups of 6 or 8 students. Each "board" has a small room available in which it meets at the customary period, and conducts a hearing on the topic assigned for that period.

The hearings may be conducted after the manner used by commissions such as the Interstate Commerce Commission. The organization of the board consists of a Chairman, a Counsel for the author's presentation, a Counsel for the league of defense against erroneous or unfounded views, witnesses, and a reporter. The duties of the chairman are: (*a*) to preside at the hearing and see that the rules of orderly and considerate procedure are followed, (*b*) to pass upon questions of relevancy, (*c*) to summarize at the end of the hearing the facts brought out. The task of the Counsel for the author's presentation is: (*a*) to state briefly the objective, (*b*) to elicit by questioning the witnesses (1) the experimental facts relating to the topic, (2) the interpretation and correlation of principles, and (3) illustrative examples showing applications or meanings of those principles. The duties of the Counsel for the league of defense against erroneous views are: (*a*) to state briefly what he proposes to establish, (*b*) to seek, by cross-examination of the author's witnesses and by direct examination of his own witnesses, any errors, ambiguities, questionable reasoning, etc., in the case built up by the author, and occasionally to make a case for an alternative development. The reporter is to record any exceptions to the chairman's rulings that may be asked.

The personnel may be changed to suit convenience, but preferably only at the conclusion of the hearing on each well-knit topic. The instructor may sit with each board about 15 minutes of each period. Under this plan each student has 5 to 10 times as great an opportunity for oral expression as in the other plan. The students thus act in turn as analyst, advocate, critic, and judge. Education consists in the balanced development of these powers. H. T. B.

The Scientific Method. See this title, page 1651.

A Neglected Phase of Visual Education. G. H. BRETNALL. *Educ. Screen*, **10**, 107–8 (Apr., 1931).—"The object itself is the best teacher; the picture is next in value, and the written or spoken description is the least effective." (But) "it is easier for the teacher to depend upon description than to go to the trouble . . . to get the illustrative material." There lies the temptation.

Illustrations, aside from the natural object itself, commonly take the form of lantern projections. Many slides are available but they are expensive, especially if they are colored. Charts are bulky and also expensive. A textbook picture may be good but makes the class using it pupil-centered rather than class-centered which is not always desirable.

Opaque projection is a "way out" of this difficulty and has a number of advantages that seem to have been passed up by the seekers for illustrative materials. The range of selection for opaque projection is as wide as the number of illustrated books and magazines on hand. Color by this goes onto the screen with no extra cost if it is in the picture. Even objects can be substituted for the pictures if they are flat and without too much depth.

The opaque projection part of a lantern is not very expensive when bought with the lantern originally. The foresighted teacher will see that it is included with the new lantern purchased. B. C. H.

Wanted—Speed in Education. H. G. DEMING. *Bull. Am. Assoc. Univ. Profs.*, **17**, 318–9 (Apr., 1931).—In describing a class in beginning general chemistry the author states, "A pace adapted to those who enter poorly prepared permits all the leaders to loaf, while one designed to spur the leaders into earnest effort soon discourages the rest."

To meet this situation the class is divided into four groups designated upper, middle, lower, and probation groups. By a system of unannounced tests students may be shifted up or down in this system of groups as outcomes warrant.

Group A, upper group, students are privileged to substitute a brief conference for a formal recitation. These students accept assignments in excess of the capacity of the average student. These assignments are determined, in a measure, by the personal tastes, aspirations, and vocational interests of these students.

Claims made are that the evil of cramming for the final examination is abolished and much bookkeeping in determining semester grades is eliminated. B. C. H.

ADMINISTRATIVE PROBLEMS AND DEVICES; CURRICULA

The Principles Which Should Govern Standards and Accrediting Practices. S. P. CAPEN. *Educ. Record*, **12**, 93–103 (Apr., 1931).—Address at the North Central Assoc. of Colleges and Secondary Schools, Chicago, 1931. The standardizing movement is some twenty-five years old. When it began, there were literally hundreds of educational institutions selling the public "educational gold bricks." Standardizing was devised primarily to stop such practice. In fulfilling this purpose it has been almost 100% successful. Unfortunately standardizing agents make laws that must be enforced literally. Moreover every standard is couched in the same general terms: in terms of hours, credits, degrees, dollars, and things—terms that give us a feeling of insecurity today when we read of the new educational program or plan of the University of Chicago. Mr. Capen answers the question "What Principles Should Govern Accrediting Practices?" very simply. He believes there should be no principles. He supports his belief by the statement that the only justification for accrediting was educational malpractice. He does not think that such has entirely disappeared, but he believes that it is not necessary to maintain such an elaborate system of machinery to control the present system. He proposes a commission whose function would be to investigate any institution thought to be unsound and to give its finding wide publicity. In like manner he answers the second question "What should govern the formulation of standards?" very briefly; in fact, in two words, namely, *educational standards*. These, he defines, are measures of different levels of capacity to do something predominantly intellectual. They measure nothing but the individual. They are applicable only to persons. Our present standards are criteria for judging institutions, not for measuring individuals. Educational standards can be used for institutional accrediting on the basis of the educational achievements of the students attending that institution. "Then," says Mr. Capen, who is from the University of Buffalo, "we shall let each institution work out its own destiny in a manner best suited to its educational theories and environment." G. O.

New York City Provision for Education for Exceptional Children. M. J. MCCOOEY. *School*, **42**, 299–300 (Feb. 5, 1931).—The paper is given over wholly to the problem of caring for the sub-normal child in New York's school system. B. C. H.

Examination and the Honor System. J. L. MERIAM. *Bull. Am. Assoc. Univ. Profs.*, **17**, 338–41 (Apr., 1931).—Conditions conducive to cheating are held, by the writer, to be almost entirely the product of the teacher's system of instruction. In support he exhibits: (1) alternate seating, (2) alternate examination question sheets, (3) examination questions so arranged as to be folded over to conceal answers as fast as the answers are written, (4) books, notebooks, and other "tools of the intellect" carefully banished from the examination room, (5) the spying proctor under whose eagle eye "conditions are not conducive to cheating." Thus it becomes a battle of wits, the teacher armed with a battery of secretly prepared tests aimed at the vulnerable points of the pupils; the pupil, if conscientious, bolstered by extensive preparation, or, if less scrupulous, armed with a crib and other "lame duck" crutches.

And there is still the question "These examinations examine—what? Ability to cheat as well as *some* other abilities. And really of what value is the testing?"

"In view of the cheating . . . may we not dispense with the examination system as the condition conducive to cheating?" B. C. H.

SOS from the Colleges. See this title, page 1651.

KEEPING UP WITH CHEMISTRY

Solid Carbon Dioxide from Mexico. J. W. MARTIN. *Ind. Eng. Chem.*, **23**, 256–8 (Mar., 1931).—In drilling for oil, near Tampico numerous wells yielding 95% CO_2 and 5% combustible gases have been brought in. The pressure is about 1000 lb. per sq. ft. and the temperature around 100°F. While oil production diminishes, the flow of gas seems to be without limit. One well has blown wild for 10 years, discharging perhaps 1000 tons CO_2 daily without reducing the pressure of adjacent wells. A small plant was built about a year ago. The oil, hydrogen sulfide, and gasoline are removed and the gas solidified without sacrifice of the original high pressure. There were produced per day and shipped to New York 10–15 tons. The loss in shipment until storage in New York amounted to 23%. The quality was equal to that produced from any other source and cost of production was lower. D. C. L.

The New Element Rhenium. W. FEIT. *Ind. Eng. Chem., News Ed.*, **9**, 122 (Apr. 20, 1931).—A brief description of the discovery and progress that has been made in the extraction of rhenium and the study of its properties. Its sp. gr. is 21.1, m. p. 3440°C., atomic weight 186.3. G. W. S.

The Nitrate Fields of Chile. *Chem. Age*, **24**, 325–7 (Apr. 11, 1931).—An illustrated article describing the mining of Chilean nitrate. Only recently, since the introduction of synthetic nitrates in the United States and in Europe, have modern mechanical mining methods come into use for this work. E. R. W.

Cottrell Precipitator. See **Dust, Soot, Smoke, and Fumes. A Classic Invention** on page 1650.

The Composition of Coal. R. V. WHEELER. *Chem. & Ind.*, **50**, 335–44 (Apr. 24, 1931).—This paper deals with the nature and ultimate composition of different coals. Methods of chemical investigation and the actions of heat on coal are discussed. E. R. W.

Something New in Foods. W. H. EDDY. *Good Housekeeping*, **92**, 102 (May, 1931).—Unbleached palm oil is sometimes used, up to as much as twenty per cent, in certain oleomargarines. When it is bleached before using, the oleomargarine is readily distinguishable from butter. When the yellow unbleached palm oil was used the appearance of the substitute was so much like the real that congress at once passed a bill taxing it to prevent unfair competition with real butter.

An examination of palm oil as a food shows it to have "edible virtues, fuel value and vitamin A potency of high order. Its use in any mixture would then make it of peculiar value as a contributor of calories and vitamin A." This does not mean, however, that oleomargarine containing, at most, only twenty per cent of palm oil would be the equivalent of real butter in these desirable qualities. B. C. H.

Listerine and Other Mouth Washes. EDIT. *J. Am. Med. Assoc.*, **96**, 1308–9 (Apr. 18, 1931).—A scathing criticism of the policy of the manufacturers of Listerine, the Lambert Pharmacal Company. The vast income of this company "from this preparation is testimony to but one thing—that modern advertising pays regardless of the actual merit of the product, regardless of any scientific demonstration of lack of efficiency, regardless indeed of possible harm that may result from unwarranted confidence in any unproved method for the prevention of disease." "Even if Listerine and similar mouth washes were actually as antiseptic as their promoters infer, they would not accomplish what is claimed for them. . . . The supreme ridiculousness of the situation becomes apparent when it is realized that the antiseptic virtues of Listerine are so infinitesimal in comparison with better antiseptics as to invalidate even modest claims made for it." S. A. L.

Poisons Threaten You at Home. E. W. TEALE. *Pop. Sci. Mo.*, **118**, 28–9 (Apr., 1931).—Millions of bottles and packages of poison containing medicines are sold each year, and Americans swallow them not knowing what they contain. Strychnine, chloroform, sulfuric acid, carbolic acid are present in many patent medicines. Some authorities advocate a law which would require that the word "Poison" be printed across the labels on all preparations containing poisons. Many poisons are beneficial in small amounts, but the reasoning that if one dose makes one feel better, two will cure, is dangerous. An overdose may be fatal, especially with headache powders and tablets.

The Food and Drug Administration concerns itself especially with cases of misbranding. Since 1907, 17,000 cases have been instituted by the government. A safe rule to follow is: "Get a prescription from a doctor, or follow the directions on the label, and don't take larger doses than the directions indicate." H. T. B.

Enamelware. ANON. *Silicate P's & Q's*, **11**, 1–2 (May, 1931).—"Vitreous enamels are complex silicates. They must be made up with regard to their expansion

and contraction with changing temperature. . . . Another very important consideration in making up enamel batches is to render them sufficiently opaque. The opacifying agent is often the most costly ingredient of the batch and must, therefore, be conserved." The proportion of silica present has much to do with the durability of the enamel against chemical attack. There is enough acid and alkali connected with the ordinary use of a kitchen sink to entirely remove the gloss of some enamels in a year.

Other considerations in the make-up of enamel are: its fusion point, the volatility of the opacifying agent, and the method of introducing the silica. The writer takes the position that silica introduced in the form of sodium silicate gives a much more satisfactory final product than that obtainable by fusion. B. C. H.

Ringworm of the Feet. W. L. GOULD. *J. Am. Med. Assoc.*, **96,** 1300–2 (Apr. 18, 1931).—This disease is "world wide and age old." Persons who frequent gymnasiums, hotels—any place where feet are exposed—are found to be infected. Although numerous remedies have been tried, there is apparently no specific medicament for this condition. In 1929, at the Albany Junior High School, each pupil leaving the shower room was asked to immerse the feet in a bath composed of a 10–15% solution of sodium thiosulfate. "Four weeks after the thiosulfate baths were installed, the ringworm infection had entirely disappeared from the Junior High School." If the bath is unhandy, a 20% powder of sodium thiosulfate in boric acid as a diluent may be used as a dusting powder in the shoes. S. A. L.

The Indispensable Uses of Narcotics in the Practice of Otolaryngology. R. SONNENSCHEIN. *J. Am. Med. Assoc.*, **96,** 1302–3 (Apr. 18, 1931).—In considering the need for narcotics in otolaryngology, one may perhaps separate the cases into two groups: those in which their use is really indispensable and those in which the administration of narcotics is highly desirable but not indispensable; in other words, there are absolute and relative indications. S. A. L.

The Indispensable Uses of Narcotics in the Treatment of Coughing. R. A. HATCHER. *J. Am. Med. Assoc.*, **96,** 1383–6 (Apr. 25, 1931).—"A thorough consideration of the causes of coughing and its rational treatment will convince one that morphine itself has only a limited field of usefulness in the treatment of coughing in the great majority of cases, and that the far safer codeine may be used with advantage in most cases in which simple measures do not cause relief." S. A. L.

The Indispensable Uses of Narcotics in the Treatment of Diseases of the Gastro-Intestinal Tract. R. A. HATCHER. *J. Am. Med. Assoc.*, **96,** 1475–7 (May 2, 1931).—A discussion of the uses and limitations of morphine and opium in the treatment of diarrhea. S. A. L.

The Indispensable Uses of Narcotics. Psychotherapy as a Substitute for Narcotics. R. B. RICHARDSON AND T. H. WEISENBURG. *J. Am. Med. Assoc.*, **96,** 1574–6 (May 9, 1931).—". . . It is apparent that fewer narcotics might be prescribed if those who treated human ills interpreted distress in terms of personality rather than in symptoms of the physical machine. It is not the intention to suggest or infer that narcotics might be banished from medical use. They still have their place; but he who prescribes such drugs on the least provocation is practicing medicine indolently." S. A. L.

The Indispensable Uses of Narcotics. The Abuse of Narcotics. B. FANTUS. *J. Am. Med. Assoc.*, **96,** 1691–3 (May 16, 1931).—"Formation of habit should be the ever-present specter to inspire fear of prescribing narcotics in chronic or recurring ailments, unless there are malignant conditions or limited tenure of life to make the habit relatively unobjectionable. Especially should physicians, dentists, nurses, and pharmacists make it their inviolable rule never to prescribe narcotics for themselves; for from among these classes is recruited a large contingent of those who become afflicted with the habitual use of narcotics. Some narcotics, as opiates and alcohol, are intrinsically habit-producing. They operate in creating the notorious craving, partly by being most efficient antagonists to the disagreeable after-effects produced by the agent itself, and partly by causing mental deterioration. But all narcotics are liable to be habit-forming by reason of their very efficiency in relieving symptoms and their inability really to cure any disease. Therefore, as soon as the effect of the agent wears off, the original condition asserts itself, demanding relief. Whenever, therefore, a narcotic is employed, it should merely be as an adjunct to the real curative treatment. It is only when cure is impossible that the narcotic habit may be a lesser evil than unrelieved suffering. In any case, an extensive range of knowledge of the many available narcotics should permit a choice of the least objectionable and yet most efficient

agent for the particular patient to be relieved; and opiates should be appealed to only as a means of last resort." S. A. L.

The Indispensable Uses of Narcotics. Professional Use of Opium and Coca Leaves, Their Derivatives and Preparations, under Harrison Narcotic Act. W. C. WOODWARD. *J. Am. Med. Assoc.*, **96,** 1771–6 (May 23, 1931).—An exposition of the legal phases of the uses of narcotics by the medical profession. S. A. L.

The Tincture of Cinchona. The Compound Tincture of Cinchona. A. LICHTIN. *Am. J. Pharm.*, **103,** 279–84 (May, 1931).—Two series of compound tinctures are discussed: (1) compound tinctures made from red cinchona bark not previously treated with acetone and (2) a series made with acetone-treated red cinchona bark. G. O.

The Scientific Examination of an Historic Document. H. T. F. RHODES. *Chem. & Ind.*, **50,** 303–4 (Apr. 10, 1931).—Description of the procedure followed in an attempt to prove that certain words in a letter from Mary Chaworth to Lord Byron written in 1813 had been effaced by some other hand than that of the writer. Successive treatments with different reagents showed that the ink used in effacing the words was different from that which was used in writing the words. E. R. W.

Transparent Life. A. VIEHOEVER. *Am. J. Pharm.*, **103,** 252–78 (May, 1931).—This is another one of the series of Popular Science Talks given at the Philadelphia Coll. of Pharmacy and Science. To those who are interested in the spectacle of life in action, the working of the inner machinery, this enumeration is very helpful and offers a field for the study of drugs and other chemicals in the various life processes carried on by transparent organisms and tissues. To the general reader it will open his eyes to the splendor of the micro-world. The article is illustrated. G. O.

SCIENTIFIC REVIEWS AND BIBLIOGRAPHIES

Synthetic Resins. W. H. NUTTALL. *Chem. & Ind.*, **50,** 299–302 (Apr. 10, 1931).—A review of the subject of synthetic resins, including a brief discussion of methods of preparation, properties, and uses. Advances in the synthetic resin industry in the future may be expected to take place along two main lines; (1) replacement of copal, kauri, and other natural gums now used in the varnish and lacquer industry; (2) production of resins especially designed to meet the needs of the electrical industry. E. R. W.

New Alkaloids Discovered 1920–1929, Inclusive. J. F. COUCH. *Am. J. Pharm.*, **103,** 242–51 (May, 1931).—Every effort has been made to include in this list all the new alkaloids. No attempt is made to treat the data critically. The facts are presented as they were published by the various authors. G. O.

HISTORICAL AND BIOGRAPHICAL

Richard Zsigmondy. (1) P. A. THIESSEN. *Chem.-Ztg.*, **53,** 849–50 (1929).—See J. CHEM. EDUC., **7,** 463–4 (Feb., 1930) for an abstract of this article. (2) *Nature*, **124,** 845–6 (Nov. 30, 1929).—See J. CHEM. EDUC., **7,** 692 (Mar., 1930) for an abstract of this article. (3) A. COEHN. *Z. Electrochem.*, **35,** 876 (1929).—Obituary. (4) A. WESTGREN. *Metallwirtschaft*, **8,** 1059–60 (1929).—Obituary with portrait. (5) LOTTERMOSER. *Z. angew. Chem.*, **42,** 1069–70 (1929).—Obituary. (6) G. TAMMANN. *Nachr. Ges. Wiss. Göttingen Geschäft. Mitt.*, **1929-30,** 54–9.—Obituary. (7) *Les Prix Nobel en 1926.* P. A. Norstedt & Söner, Stockholm, **1927,** pp. 73–6.—Biography and portrait. (8) V. JUNK, "Die Nobelpreisträger, Dreissig Jahre Nobelstiftung," Verlag Michael Winkler, Wien, Leipzig, **1930,** pp. 128–9.

The Scientific Examination of an Historic Document. See this title above.

Dust, Soot, Smoke, and Fumes. A Classic Invention. F. G. COTTRELL. (Taken from *Annual Report of the Smithsonian Institution 1913*). *Sci. News Letter*, **19,** 283–5 (May 2, 1931).—The precipitation of suspended matter, whether in gases or liquids, may be accelerated by electricity in the form of either direct or alternating current.

An alternating current, by its field effect upon suspensions, tends to agglomerate the suspended particles into larger aggregates.

Such a process, however, is too slow to settle out suspensions in moving gases of flues. In such cases unidirectional currents are more satisfactory.

To get such currents, with an effective precipitation, a high potential difference between circuit terminals is necessary. Direct current generators are not satisfactory for such purposes so the solution was ultimately found in a special rotating contact maker that commuted a high potential current from a transformer. By using electrodes, one a plate and the other a series of points, or their equivalent, with potentials across them of from 20,000 to 75,000 volts, satisfactory precipitation of flue gases is

accomplished. By the installation of the electrodes at different points of the flue in relation to the temperature gradient, first dust, then materials that were vapors at higher temperatures can be brought out of the gases. A species of fractional condensation is thus achieved.

The same mechanism can be used to rapidly desiccate solutions such as milk or to re-collect lime dust after it has cleared some exhaust gases of traces of chlorine.

B. C. H.

EDUCATIONAL MEASUREMENTS AND DATA

Educational Research in the Field of Emotion. F. H. LUND. *Educ. Record*, **12**, 138–43 (Apr., 1931).—Educational research has paid little attention to the field of emotion in the past. Research has centered about the nature and form of simple stimulus-response relationships without reference to the dynamic conditions of the individuals which set these responses into action. No genuine understanding of the problems of dynamic psychology will be attained until more is known about the autonomic nervous system. We need to know more about the specific organs involved in emotional expression and the extent to which they can be modified and controlled. This sort of research will require the coöperation of large numbers of students and investigators. It would be necessary to find out and establish norms of educational achievement for given intelligence levels; it would also be necessary to discover as much as possible the circumstances surrounding students—their economic status, their social status, and their physical and health conditions. Such a study as comprehensive as this would serve to throw light upon native and acquired traits. It would help to determine also the relative effectiveness of different forms of motivation now in use in the school room.

G. O.

THE PHILOSOPHY OF EDUCATION

SOS from the Colleges. H. A. SMITH. *Forum*, **85**, 316–20 (May, 1931).—"The educational pyramid shows an increasingly thin and uncertain middle section. At the bottom are the schools, public and private; on top rest the universities—impressive, effective, a little heavy; in between the colleges." Formerly America was satisfied with colleges, but Germany's effort toward bigger and better universities stimulated a similar movement here. But American students were not trained, as were those in Europe, to jump from school-mindedness to university-mindedness. College is needed in America to exert its "transitional influence." All is not well in our colleges. "... Competition has become a major influence where partnership should be the keynote." The university-minded group measures progress by productive research; the college-minded group insists that inspiring human teaching is more important than scholarship during undergraduate years. "Both teachers and research workers are indispensable, but their work is consecutive rather than competitive." Rarely is the same person capable of excelling in both types of work. In business concerns and law offices, different members supply different qualities, but in the modern faculty there is competition between departments and, because of gradations in rank and salary, also within departments. Now, to attain higher rank, research must be produced. The researcher acquires a trading value, while he who is merely an inspiring teacher finds this difficult. The system is to blame. Faculties should be divided in two groups; one primarily researchers and the other primarily teachers; but both groups to do both types of work. Academic rank might be abolished entirely. Salary differences might be erased and age and length of service made the common basis for all. "Would any individual lie back and let his associates carry his work?" "No honorable man shirks a group obligation." S. suggests a scheme of organization for the modern college-university.

S. A. L.

The Scientific Method. R. R. SPENCER. *Hygeia*, **9**, 230–3 (Mar., 1931).—The scientific method is simple enough that the average individual may accomplish much through its use. A group of critics charges that animal experimentation is cruel and adds nothing to knowledge. Another group is asking such questions as: Is it the only method by which we may approach the truth? Do science and religion conflict? Shall we soon reach the limits of the "knowable"? A recent writer complains that science has failed on three counts: (1) it has failed to explain the meaning of life, (2) it has not produced a satisfactory system of education, and (3) it has not made people happier. Philosophy and religion have been unable to answer the first despite the thousands of years they have had, so that it is a compliment to science to be expected to answer it. In regard to education, it may be said that progress is being made.

Happiness is too intangible to measure accurately, but it would appear that modern conveniences should add materially to happiness.

Every individual is born with some endowment of the research spirit. Education should develop this. One must inquire, search, doubt, analyze, investigate, and discover the truths of nature. "The wish must never be the father to the thought." "Why should not every one serve for a time in the 'front trenches of the siege of truth.'" H. T. B.

Examination and the Honor System. See this title, page 1647.

Inaugural Address. R. G. SPROUL. *Educ. Record*, **12**, 104–24 (Apr., 1931).—Pres. Sproul in the Inaugural Exercises held at Berkeley emphasized strongly his belief in one state university; that is, not only an institution that is called a state university but only one state-supported institution in the field of higher education. The counsel of experts is positive and unanimous against dividing the efforts of the state in this field. He also stressed the need of our public school system to provide a number of highways of varying grades leading to many useful careers and to open them to all whose talents and desires are adequate. He interprets one function of the public school system to be to discover those who have the capacity. Education must provide more than one channel for the varying talent and industry of her charges. To meet this need he does not advocate lower standards of admission but more intelligent ones. (See abstract of "The Principles Which Should Govern Standards and Accrediting Practices," page 1647); not more colleges or universities of the traditional type but altogether different institutions which will more suitably train those students and get them into their life work sooner; not more four-year colleges that will admit anybody but another type of institution extending not more than two years beyond the high school which will provide curricula for those whose talents do not lie along the line of a career but who are interested in higher education—a junior college as an extension of general education and teachers' colleges honestly devoted to the training of those who will be elementary teachers. G. O.

The School and the Community. E. W. BUTTERFIELD. *Educ. Record*, **12**, 125–37 (Apr., 1931).—An address before the Dept. of Supts., N. E. A., Detroit, 1931. Imaginary cases—two bright and six dull—are taken as fair samples of a graduating class and their futures are pictured fifteen years later. What is the miracle of transformation of these hypothetical cases? From the school door they have rushed forth erect and healed of their scholastic infirmities. Why? The modern school aids those who are word-minded. Intelligence has come to have a restricted meaning, to describe those who are school bright and those who are school dull. High schools and colleges seem to believe that school bright means college bright, and they set up elaborate selective systems based on the assumption that he who is school dull will be college dull. The schools are therefore organized against the school dull. Mr. Butterfield's conclusion is that the school stands between the home and the community. Its task is to take children as they are and to train them for life as it is. G. O.

The "Board of Inquiry" versus the "Lecture-Recitation" Method of Education. See this title, page 1646.

Train Bright Pupils for Leaders. J. L. TILDSLEY. *School*, **42**, 527 (Apr. 2, 1931).—"Schools must concern themselves with the bright students because to them society must look for leaders." There is a need that we "abandon faith in the magic of subject matter; magic lies in the teacher," says this author. "Subject matter is the medium through which to work; it is not an end in itself. . . . The best education could be gained in a school were each teacher a genius or at least a gifted, enthusiastic teacher, for education truly comes when mind touches another mind which is rich and cultivated and well-disciplined." B. C. H.

CONTEMPORARY NEWS AND COMMENTS IN CHEMISTRY AND EDUCATION

Presidential Address to the Chemical Society. J. F. THORPE. *Chem. & Ind.*, **59**, 278–81 (Apr. 3, 1931).—President Thorpe reviews the condition of the Chemical Society, and points out the chief aims of the society. Attention is called to the fact that three abstract periodicals (*British Chemical Abstracts*, *The Zentralblatt*, and *Chemical Abstracts*) cover essentially the same field in chemistry. A great saving in space and money might be accomplished if this duplication of work could be avoided by some plan of coöperation that could be agreed upon by the publishers of these journals. The two English-speaking societies, at least, should be able to come to some such agreement. E. R. W.

The Experimental College. EDIT. *School*, **42**, 546 (Apr. 9, 1931).—This is an editorial upon the Experimental Wisconsin College which, under the direction of Doctor

Alexander Meiklejohn, has been in operation the past four years. "There is every indication that (it) . . . is going to be abandoned." Its deletion has come largely through the critical attitude of the faculty members of other departments of the university. B. C. H.

American Chemical Society Prize Essay Contest for High Schools. See page 1654.

Retirement Funds for Teachers in California. See page 1655.

Michigan's Alumni University. See page 1655.

John Simon Guggenheim Memorial Foundation Fellowships for Advanced Study Abroad in 1932. See page 1656.

American Scientists Gather in Pasadena for Meeting of American Association for the Advancement of Science. See page 1658.

Rumford Medal Awarded Dr. Karl T. Compton. See page 1663.

Howard, Foe of Insects, Gets Capper Award. See page 1663.

New Auto and Plane Fuel Proof against Dropped Machines. See page 1663.

Rocks Yield Secrets after Acid Treatment. See page 1664.

100 Per Cent Efficient Light Made but Not for Use. See page 1664.

New Color Movies Use Tiny Colored Squares. See page 1665.

The 36th General Meeting of the German Bunsen Society for Applied Physical Chemistry Held in Vienna, May 25–28, 1931. See page 1666.

The 5th General Meeting of the Dechema, Vienna, May 28–30, 1931. See page 1666.

Some Laboratory Hints. 1. The "lead" in your glass-marking pencil pushes out while writing with it. *Remedy:* Dip the non-writing end in thick collodion—then let it dry.

2. The leveling bulb of your Orsat or other apparatus requires a support. *Answer:* Screw a metal test-tube holder to the under side of the edge of your desk: the holder clamps the bulb securely and yet it is really disengaged.

3. You require a constant temperature oven at 37°C. *Answer:* A store box of about 4 cu. ft. capacity, insulated by mineral wool from a larger one in which it rests will maintain such a temperature if two 10-watt bulbs be kept burning within the inner box.

4. Your vacuum desiccator needs grinding to insure a constant negative pressure. *Remedy:* Apply a stopcock grease with $^1/_3$ more rubber in it than ordinary formulas call for.

5. Bubbles obscure the reading of melting points in such an apparatus. *Remedy:* Treat the offending surface with lanolin (cholesteryl esters) to reduce the surface tension at the glass-water interface. Note: Bull Durham sack rubbed over the surface instead of lanolin accomplishes the same purpose. Try it on your wind-shield.

6. Cleaning solution does not cleanse a piece of glassware. *Remedy:* Try 50 cc. C_2H_5OH + 5 cc. conc. HNO_3 in an open beaker. Many organic substances may be removed in this way, but beware the sudden development of NO_2 and never use the mixture in a closed vessel (buret closed at one end; separatory funnel with cock and stopper closed, etc.).—*The Catalyst*

Sulfur Particles Fatal to Fungi of Plant Ills. Sulfur, the element traditionally associated with things infernal, has a blighting and fatal effect on some of the fungi responsible for plant diseases. But to do its work a particle of the solid sulfur itself must come into contact with the thread-like body of the fungus. This has been discovered by Dr. William Goodwin of South Eastern Agricultural College, Wye, England, who reported on his experiments at the recent meeting of the Fifth International Botanical Congress meeting at Cambridge, England. Dr. Goodwin's work was designed to settle the disputed question whether sulfur volatilized by heating could also kill fungi; he found that it could not. He also found that the effectiveness of powdered sulfur in washes and sprays is heightened by the presence of an alkali.—*Science Service*

Contemporary News in Chemistry and Education

AMERICAN CHEMICAL SOCIETY PRIZE ESSAY CONTEST FOR HIGH SCHOOLS

DR. RAY LYMAN WILBUR, Secretary of the Interior, the Chairman of the American Chemical Society Prize Essay Contest National Awards Committee, announced on June 29, 1931, that the following six high-school students have been designated winners of the 1930-31 National Contest. The prizes to be awarded the winners are the gift of MR. AND MRS. FRANCIS P. GARVAN of New York City, made in memory of their daughter PATRICIA, and consist of four-year scholarships paying tuition and five hundred dollars annually at any college or university in the United States. The winners and the topics of their essays are as follows:

ANNE STRINGER, The Roland Park Country School, Baltimore, Md., "The Purification of Municipal Water."

ELIZABETH DEW, Arkadelphia High School, Arkadelphia, Ark., "The Rôle of Chemistry in Music, Painting, Radio, and Motion Pictures."

FRANCES GELABERT, Tulsa Central High School, Tulsa, Okla., "Fertilizers in Agriculture."

GERALDINE E. RHOADS, Belleville High School, Belleville, N. J., "Is the Use of Gas in Warfare Justifiable?"

JOHN STEWART BARNEY, Brattleboro High School, Brattleboro, Vt., "How the Home Can Be Made More Livable through Chemistry."

MARJORIE SHUMACKER, Girls' Preparatory School, Chattanooga, Tenn., "Chemistry and the Utilization of Waste Materials."

The forty-two high-school students who have won similar national prizes in previous contests of the American Chemical Society came from the following states: Alabama, Arizona, Arkansas, California, Connecticut, Georgia, Idaho, Illinois, Indiana, Iowa, Louisiana, Maryland, Massachusetts, Missouri, Montana, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, Oklahoma, Oregon, Rhode Island, Pennsylvania, South Dakota, Tennessee, Texas, Vermont, Washington, Wisconsin, and Wyoming, and matriculated at the following colleges: Yale, Vassar, Brown, Butler, Carleton, Cornell, DePauw, Harvard, Lehigh, Louisiana State, New Mexico, Northwestern, Radcliffe, Stanford, Whittier, and the Universities of Arizona, California, Chicago, Georgia, Iowa, Maryland, Michigan, Missouri, Nevada, North Carolina, Oregon, Pennsylvania, Texas, Virginia, Washington, and Wisconsin. These include the sons and daughters of college presidents, bankers, lawyers, judges, cigar makers, house painters, clerks, farmers, mechanics, miners, teachers, and chemists. Among these are three foreign-born boys, all of whom were forced to help earn money for family support while attending high school. The first, now at Yale, did a hired man's work on his father's farm, and had to walk five miles to and from school each day as well; the second, now at Brown, was a hotel bus boy, and the third, now at Harvard, was a printer's helper. Others are a recent Queen of the Mardi Gras at New Orleans who completed a four-year course at Vassar in three and is now doing special research work in chemistry; a West Virginian who earned a B.A. degree at Lehigh in three years and a doctor's degree this year at Harvard, and will go to Oxford in the fall as a Rhodes scholar; a Centralia Washington orphan boy, now an instructor in chemistry at the University of Pennsylvania; a son of a teacher of Hebrew, now a member of the Connecticut and New York Bars; a Texan, recently promoted to the superintendency of a large utility company in his native state, while others have entered business, professional or teaching fields, or are still attending college.

The Essay Contest was designed by Mr. and Mrs. Garvan to stimulate widespread interest in chemistry by the oncoming generation. It was started in 1923 and will conclude this year.

Each year six prizes of Garvan scholarships, paying tuition and $500 cash annually, have been awarded the national winners, and in addition over $6000 in twenty dollar gold pieces have been distributed each year as prizes to the 306 winners in the preliminary state and territorial contests.

In these eight annual competitions, about four million children have written essays, necessitating on their part a thorough study and understanding of chemistry in modern life.

The Committee extended the thanks of all friends of American chemistry to Mr. and Mrs. Garvan who, they said, had spent over $500,000 on these contests.

RETIREMENT FUNDS FOR TEACHERS IN CALIFORNIA

The U. S. Daily prints a communication from MR. STUART R. WARD, executive secretary, commission for study of educational problems of the State of California, giving a description of the changes recommended in the provisions for the teacher retirement fund in California, a fund built up by joint contributions from teacher and state out of which the teacher is to receive a regular stipend on retiring from service.

A measure was passed by the legislature of 1913 by which an annual salary of $500 was to be paid to teachers who should retire under the provisions of the act.

To qualify for retirement a teacher must have taught in the public schools of the nation for at least 30 years, the last 15 of which must have been in California. He must also have paid into the retirement fund an amount equal to $1 per month for the full 30 years.

This 1913 retirement salary, while not large, was fairly satisfactory at the time, being then the equivalent of somewhat more than $800 in present-day values.

The legislature of 1927 provided for a commission of investigation to study the measure conjointly with a committee of the California Teachers Association to determine the question of actuarial soundness. The report of this commission was not reassuring. In the meantime the teachers of the state have not been idle, and proposals for various types and varying amounts of retirement salary have been offered. Some of these were considered by committees of the 1929 legislature but all failed of passage.

It has seemed advisable for the Commission for the Study of Educational Problems to do no more than outline in a general way certain provisions under which a retirement salary fund should be created and should operate. The Commission has therefore recommended:

1. That the amount of the retirement salary for teachers in California be increased.
2. That teachers be required to contribute yearly to the retirement salary fund an amount equal to that provided by the state.
3. That no plan be adopted and passed by the legislature which has not the approval of competent actuaries.
4. That in making any changes in the present law or in substituting therefore another measure, the interests of present annuitants be fully safe-guarded.

—*School & Society*

MICHIGAN'S ALUMNI UNIVERSITY

"So many men repeat the commonplace: 'I wish I could go to college again,'" says WILFRED SHAW, director of alumni relations at the University of Michigan, "that we took them at their word and set up a series of classes for them during commencement week in June, 1930. It went with enthusiasm. Old graduates testify that they learn better than when they were underclassmen. The professors found the alumni classes more lively than are the regulars. The Alumni Institute has come to stay." For five days im-

mediately succeeding commencement this series of courses were given at Ann Arbor, five successive discussions in each course, beginning on Tuesday, June 23, and closing Saturday, June 27. The program was as follows:

9.00 A.M.

"Problems of Local Government." PROFESSOR THOMAS H. REED.
"Evolution in Its Latest Interpretations." PROFESSOR A. F. SHULL.

10.00 A.M.

"The Contemporary State." PROFESSOR OSCAR J. CAMPBELL.
"Contemporary Currents in Philosophy." PROFESSOR D. H. PARKER.

11.00 A.M.

"Public Control of Industry." PROFESSOR I. L. SHARFMAN.
"Contemporary European and American Art." ASSOCIATE PROFESSOR BRUCE M. DONALDSON.

1.00 P.M.

"The Geological Character Line in Landscapes." PROFESSOR WILLIAM H. HOBBS.
"Genetic Principles in Child Behavior." ASSISTANT PROFESSOR MARTHA G. COLBY.

2.00 P.M.

"Contemporary Social Evolution." ASSOCIATE PROFESSOR R. C. ANGELL.
"The Symphonic Poem." PROFESSOR EARL V. MOORE.

The registration fee was $10.00 and covered as many courses as the applicant elected. The spacious club buildings, the Michigan Union and the Michigan League, took care of alumni at $5.00 a day, meals and lodgings. A feature of the week was a series of plays given in the Lydia Mendelssohn Theater by a repertory company headed by TOM POWERS, VIOLET HEMING, and ERNEST COSSART. The new University Golf Course offered special advantages. Facilities for swimming, hand ball, and tennis were utilized.

Special reading and study lists had been prepared by the members of the faculty of the Alumni University for those who wished to prepare themselves in some measure for the courses given, although such preparation was not requisite. These lists are published in this announcement. The university library set aside a study room on the first floor of the library building where these books were available for consultation and reference.

PRESIDENT RUTHVEN argues "once a student always a student." In his invitation he says: "I can see no reasonable ground for assuming that the university's educational relations with its students terminate at that point when the student is handed his diploma. It was because of this feeling that the Alumni University was inaugurated last year on this campus. The experiences of those alumni who attended the 1930 session were so pleasant and profitable that I hope many more will plan to take part in the courses which have been announced for this June."—*School & Society*

JOHN SIMON GUGGENHEIM MEMORIAL FOUNDATION FELLOWSHIPS FOR ADVANCED STUDY ABROAD IN 1932

In order to improve the quality of education and the practice of the arts and professions in the United States, to foster research, and to provide for the cause of better international understanding, the JOHN SIMON GUGGENHEIM MEMORIAL FOUNDATION, established by former UNITED STATES SENATOR and MRS. SIMON GUGGENHEIM as a memorial to a son who died April 26, 1922, offers a limited number of Fellowships, tenable abroad under the freest possible conditions, for research in any field of knowledge and for creative work in any of the fine arts, including music. Appointments to Fellowships are made by a Committee of Selection, subject to ratification by the Board of Trustees.

The Foundation now offers a limited number of Latin American Exchange Fellowships to citizens of Argentina, Chile, Cuba, and Mexico, for work in the United States of America; and to citizens of the United States for work in Latin America. In 1932 the Latin American Exchange Fellowships will be extended to Porto Rico. Latin American Exchange Fellows from the United States will be chosen on the same basis as all other Fellows from this country.

1. The Foundation plans to maintain annually approximately sixty Fellows.

The Fellowships are intended for men and women of high intellectual and personal qualifications who have already demonstrated unusual capacity for productive scholarship or unusual creative ability in the fine arts. For the present, Fellowships in music will be awarded only to candidates who have plans for creative work in musical composition, or for research in the history or theory of music.

2. Fellowships are open to men or women, and to married or unmarried candidates. Fellows are normally of ages between twenty-five and forty years; but for 1932-33 the Committee of Selection has been empowered, in exceptional cases only, to make a limited number of grants to scholars older than forty. The Fellowships are open to citizens (or, in exceptional cases, to permanent residents who are not citizens) of the United States, irrespective of race, color, or creed.

3. The stipend will in the normal case not exceed $2500 for a year of twelve months. The tenure of Fellowships will be adjusted to the purpose and scope of the studies of each individual. Appointments will be made ordinarily for one year; but plans which involve two or three years' work will be considered by the Trustees. In special cases the Trustees will grant Fellowships for terms shorter than one year, with appropriate stipends. Members of the teaching profession who have received sabbatical leave on full or part salary will be eligible for appointment.

4. The Committee of Selection will require evidence that candidates are persons of unusual capacity for research, demonstrated ordinarily by the previous publication of contributions to knowledge of high merit, or that they are persons of unusual and proved creative ability in some one of the fine arts. Definite plans for their proposed foreign study must be presented by all candidates. The Foundation will consult with responsible scholars and artists regarding the value and practicability of the projects presented, and the personality and promise of the applicants.

5. The Trustees may subsidize the publication of important contributions to knowledge produced by holders of Fellowships on the Foundation; but they do not undertake to aid in publishing all works so produced.

6. Fellows are expected to present a complete report to the Foundation on retiring from their Fellowships, and informal reports at such times as the Foundation may suggest. Applications for reappointment must be accompanied by preliminary reports of work accomplished. Such applications should be received at the office of the Foundation before February 1, 1932.

7. Applications for Fellowships must be made in writing on or before November 1, 1931, by the candidates themselves, in the form prescribed, addressed to HENRY ALLEN MOE, *Secretary*, John Simon Guggenheim Memorial Foundation, 551 Fifth Avenue, New York City. Final selection of Fellows for 1932-33 will be made early in March, 1932. Application forms will be mailed by the Secretary upon request.

Of the Fellowships granted in 1931 to citizens of the United States, the following recipients are doing research in chemistry: (1) DR. ERMON DWIGHT EASTMAN, associate professor of chemistry, University of California: studies in non-isothermal systems of ionic entropies, and of electrons in metals, at the Universities of Leipzig and Munich. (2) DR. GEORGE SUTTON PARKS, associate professor of chemistry, Stanford University: thermochemical studies upon organic compounds, in certain European laboratories. (3) DR. THOMAS ERWIN PHIPPS, associate professor of chemistry, University of Illinois: the continuation of studies of problems in the field of molecular rays, chiefly at the Institute for Physical Chemistry of the University of Hamburg. (*Renewal.*) (4) DR. GEORGE SCATCHARD, associate professor of physical chemistry, Massachusetts

Institute of Technology: studies in the theory of liquid solutions, in consultation with certain European scholars.

AMERICAN SCIENTISTS GATHER IN PASADENA FOR MEETING OF AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

General

American men of science joined with guest scientists from other lands in discussing recent important advances and discoveries, at the meeting of the American Association for the Advancement of Science which held its sessions in Pasadena from June 15 to 20. The discussions ranged all the way from the antiquity of man in America to the structure of the atom; from the way plants gather sunlight and use it in the building of food to the best way to keep earthquakes from ruining cities.

Since the meeting was held on the Pacific side of America, in a region where the problems and possibilities that lie in the oceans figure largely, a prominent place on the program was given to a symposium on problems in oceanographic research, under the chairmanship of DR. T. WAYLAND VAUGHAN, director of the Scripps Institution at La Jolla, California. Another symposium dealt with important discoveries of evidence of human occupation of America, especially in the Southwest, during times when mastodons, giant ground sloths, and other now extinct animals of the Ice Age were still alive. Other groups took advantage of the high development of astronomy on the Pacific slope to discuss problems connected with the sun and stars, particularly their electrical, magnetic, and chemical phenomena.

The principal address of the meeting was delivered by the president of the Association, DR. FRANZ BOAS of Columbia University, on "Race and Progress." This was given on Monday evening, June 15. Other evening lectures were given by DR. H. D. ARNOLD of the Bell Telephone Laboratories, DR. ARTHUR L. DAY of the Carnegie Institution of Washington, and DR. CHARLES A. BEARD, noted historian.

The Pasadena meeting was the eighty-eighth national gathering of the American Association for the Advancement of Science. It marks a new policy, for hitherto the principal meeting of the Association has for many years been held in the winter. Beginning with the present, there will be two meetings a year, one during the Christmas holidays and the other in the summer.

The American Association for the Advancement of Science is the largest general scientific body, with a membership list of over 16,000. It is a non-exclusive organization, for persons who are not professional scientists are welcomed to membership and to attendance at its meetings if they are interested in science.

Fastest Man-Made Projectiles Reported by Physicists

Methods of producing and using the fastest particles made by artificial means on the earth, speeding as fast as 184,000 miles per second, were discussed by physicists assembled in Pasadena in connection with the joint meeting of the American Physical Society and the American Association for the Advancement of Science.

The speakers included: DR. W. D. COOLIDGE of the General Electric Company, PROF. E. O. LAWRENCE of the University of California, DR. C. C. LAURITSEN of the California Institute of Technology, and DR. M. A. TUVE of the Carnegie Institution of Washington.

Millions of volts are now quite familiar in the laboratories of all these men. By the aid of electrical pressures up to even five million volts, electrons and atomic nuclei are being speeded up to rival and surpass the rays of radium, which have been of such great importance in both physics and medicine.

Dr. Tuve reported progress made in his attempts to speed up protons with the help of 1,300,000 volts. So far pro-

tons of the full speed expected have not yet been produced but 800,000-volt protons were easily obtained under these conditions. By introducing a source of protons into the tube in which the experiments are carried out it is hoped to get full-speed particles.

Dr. Tuve mentioned the initial success of a method which promises to build up voltages of ten million volts, by use of the so-called Faraday cages. Above this figure serious difficulties are anticipated.

Dr. Tuve also described his plans for attempting artificial disintegration of atoms by bombarding them with the high-speed particles. An expansion chamber in which the collisions can actually be photographed is being constructed. Stereoscopic cameras will be used.

Prof. E. O. Lawrence told of his success at Berkeley in producing million-volt mercury ions.

Prof. C. C. Lauritsen discussed the working of the 900,000-volt X-ray tube with which it is hoped soon to attempt biological applications. Dr. Lauritsen produced the high voltage by means of transformer as in the conventional X-ray tube operation whereas Dr. Tuve uses a form of Tesla coil with which higher voltages are possible. Dr. Lauritsen's rays are more intense and dangerous to the worker.

Dr. W. D. Coolidge told of the difficulties encountered in designing X-ray tubes for operation at these high voltages. A great reduction in both space and electrical hazard is possible, he said, by operating both the tube and the high-voltage source immersed in oil. No portion of the high-voltage circuit will be exposed to the air. The glass used for the tube should be free from the elongated bubbles found generally in drawn glass tubing.

Chemistry Being Reduced to Mathematics

How the formation of chemical compounds is being explained mathematically by the new theories of physics was told in a symposium before the Association.

DR. W. HEITLER of the University of Göttingen, Germany, DR. LINUS PAULING of the California Institute of Technology, and DR. J. C. SLATER of the Massachusetts Institute of Technology, all of them experts in this matter, explained various aspects of the theory to the meeting.

Before the invention of the new quantum theory, chemists had been unable to understand the formation of a great class of chemical compounds, those in which there is no direct electrical attraction. Ways have now been found, the speakers revealed, of explaining these and many other chemical facts in strict mathematical terms.

The new mathematical theory confirms completely the idea of PROF. G. N. LEWIS of the University of California that the non-polar type of linkage between atoms consists of two electrons paired. Only atoms in which there is an unmated electron can form compounds of this sort.

Further, said Dr. Heitler, the quantum theory shows that the electron possesses quite a remarkable property, its spin. The electron has an axis which cannot assume all directions in space. For two adjacent electrons the axes must either be parallel or antiparallel. If the spins, and therefore axes, are in opposite directions there is an attractive force between the molecules. This is the chemical force.

Dr. Pauling was able to explain why some atoms combine and others not. The new theories will also explain the strength of chemical attractions, magnetic properties, and the angles made by the atoms in compounds.

Heart of Atom Pictured to Scientists

Scientists were given a look into the heart of matter and shown diagrams of the structure of the atomic nucleus when PROF. WENDELL M. LATIMER of the University of California presented to the Association a new theory of the way in which the central portion of the atom is put together.

This is the ultimate and final step

determining just what is the structure of the material things about us. In the past few years scientists have carried their probings into the makeup of matter step by step into the realms of the minute in size. Beneath the seemingly solid surfaces of metals and other substances with which we have daily contact, they first found a multitude of regularly arranged crystals, row on row of them, each made up of molecules, which in turn were shown to be definite arrangements of atoms. X-rays have aided greatly in this exploration of sub-microscopic crystal worlds. The atom was shown to be fashioned as a very heavy nucleus surrounded by very light particles or waves known as electrons. Prof. Latimer has assumed the task of discovering the architecture of that internal citadel of the atom which has kept out prying scientific explorers.

Previous investigators have pictured the nucleus of the atom in terms of the number of protons, or hearts of hydrogen atoms, and electrons that are present, Prof. Latimer explained. In iron, for instance, the nucleus was known to consist of 56 of the protons, as the hydrogen nuclei are called, and 30 electrons or units of electricity. The radio-active disintegration of elements like radium gave a clue to how the protons and electrons were arranged in the nucleus. Disintegrating matter gives off both unattached electrons in pairs and bundles of four protons and two electrons known as alpha particles. These particular bundles known as alpha particles are known to be also the atomic hearts of helium, the inert gas that is used to inflate American airships. Other research has shown that these protons and electrons are spinning and opposite spins play an important part in keeping the nucleus together.

These were the materials used by Prof. Latimer in building together his new view of the heart of matter. First he arranged alpha particles in a tetrahedral pattern, that is, at the corners of a triangular pyramid. Then he assumed that each of these alpha particles is itself a tiny tetrahedron of four protons with a pair of electrons happily spinning at its center. This builds a nuclear structure that satisfies all science knows about the atomic nucleus. Prof. Latimer presented it as the best picture that can now be drawn of the ultimate in the structure of matter.

The inhabitants of the nucleus of the atom are much more crowded than the electrons on the outside, PROF. R. H. FOWLER, mathematical physicist of the University of Cambridge, England, told the Association. The nucleus is excessively compact, while the atom as a whole is much more diffuse, though still quite small.

"The difference," said Prof. Fowler, "seems to result from a difference in the social legislation in the two states, Atom and Nucleus. Electrons, inhabitants of the state Atom, are controlled by severe anti-slum legislation which forbids more than one electron to occupy any one tenement. Alpha particles, inhabitants of the state Nucleus, will have nothing to do with such restrictions and insist on all sharing the same tenement whenever they get the chance."

Prof. Fowler explained that man's exploration of the state of the atomic nucleus was progressing steadily and that the energy laws of the heart of the atom are being discovered to be very similiar to those that PROF. NIELS BOHR found to apply to the atom as a whole.

Just as the atoms have definite energy states in which they respond much as a violin string will vibrate to a definite sound vibration, so the nucleus has definite levels of energy within it that can be probed by curious physicists.

Portions of the nucleus cannot be knocked out in the same way that electrons can be removed from atoms by bombardment, Prof. Fowler explained, but the physicists can watch alpha particles come out of their own accord during natural disintegration. These alpha par-

ticles are the hearts of helium atoms and with protons and electrons as somewhat trivial additions they form the nuclei of all atoms. The energy changes that occur when alpha particles and protons come out of the atom's nucleus are giving a number of investigators all over the world clearer pictures of the constitution of the nucleus.

Waves of Electrons Will Tell of Crystal Structure

Waves of electrons will soon allow the scientist to obtain a clearer picture of the internal structure of crystals than ever before possible, DR. C. J. DAVISSON of the Bell Telephone Laboratories, New York City, predicted to the Association.

Very short wave-lengths are available in electron waves and this results in greater power to photograph the fine crystal structure of matter. Dr. Davisson is a pioneer in the use of electron waves since he won international fame a few years ago by proving that electrons acted like waves in much the same way as light and X-rays. He has also developed lenses for concentrating the beam of electrons. Since the electron is what may be termed a particle of electricity, his work bridges the previous gap between matter and electricity.

Just as shortening the wave-length of light used in illuminating a microscope allows smaller objects to be seen, use of electrons made visible by their effects on photographic plates allows physicists to study more minute structure in crystalline matter, Dr. Davisson explained. The electron waves are diffracted by crystals and give rise to diffraction patterns which are quite similar to those produced by X-rays. X-ray studies have given much information on matter's structure in the past decade.

The scattering power of atoms is about a million times greater for electron waves than for X-rays, Dr. Davisson explained. The electron waves will therefore give information chiefly regarding the structure of surfaces of crystals, whereas the X-rays give information about the structure of the bodies of crystals. He also expects that the electron waves will allow the study of layers of gas attached to the surfaces of metal crystals.

DR. P. W. BRIDGMAN of Harvard University discussed metal crystals and explained that much more is known about simple common salt crystals than about simple metal crystals. DR. FRITZ ZWICKY of the California Institute of Technology described newly discovered secondary structure of crystals which physicists expect will aid them to a better understanding of how matter is put together.

Gamma Rays and X-Rays Have Different Effects

More exact knowledge of the differing biological effects of radiations used in treating tumors and other diseased conditions was urged upon medical experimenters and practitioners by DR. G. FAILLA and DR. P. S. HENSHAW of Memorial Hospital, New York City, who spoke before the Association.

The two New York scientists described a series of experiments in which they tested the effects on various living things of equal-energy doses of X-rays and gamma rays from radium. Gamma rays are radiations similar to X-rays, but of shorter wave-length and more penetrating. The effects tested included the extent of slowing down of wheat seedlings, percentage of killing in insect eggs, and degree of skin reddening or erythema.

In one series of "shots" it was found that parallel doses of X-rays and of gamma rays slowing down the growth of the shoot of wheat seedlings to the same extent had different slowing effects on other parts of the plant and on other objects. The gamma rays were 29 per cent more effective than the X-rays in slowing down root growth and 36 per cent more deadly to insect eggs; but they were 57 per cent less effective in causing artificial sunburn.

This latter point is of some importance in practical medicine, for the effectiveness

of a given dose of radiation on a tumor or other tissue under treatment is usually judged by the redness of the overlying skin. But in the experiment the more destructive rays had the lower skin-reddening power, showing that unless the quality of radiation is taken into account the skin-reddening effect cannot be very closely relied on as an index to its other effects.

X-Rays Most Destructive to Young, Growing Cells

X-rays in sufficient doses are destructive to all kinds of living cells, but they are most destructive to cells that are physiologically young and active.

This is one of the basic physiological facts that underlie radiotherapy, DR. ARTHUR U. DESJARDINS, of the Mayo Clinic, told the Association. It follows from this principle that tissues that remain "chronically young" respond to X-ray dosages much smaller than those needed for effect on maturer tissues.

The most sensitive of all the cells in the human body are certain classes of white blood corpuscles, and the glands and other tissue masses where these are found most thickly are also very sensitive to the destructive rays. Dr. Desjardins inclines to the opinion that the easy destructibility of these white blood cells is at the bottom of the value of X-ray therapy in certain inflammatory conditions. White blood corpuscles crowd around foci of infection, causing inflammation. The X-rays break them down, releasing the germ-destroying substances they have formed within themselves, and thereby hasten the death of the trouble-causing bacteria.

Certain kinds of tumors and cancers can be treated with X-rays because the cells constituting them are physiologically younger than the surrounding tissues. The diseased growths are therefore destroyed by doses of X-rays that do no appreciable harm to the healthy tissues.

The most sensitive of normal body tissues are the mucous surfaces lining the digestive and certain other cavities. Muscle, bone, and nerve tissues are among the most resistant.

New X-Ray Cancer Tests

Nationally famous cancer research men await results of forthcoming skin disease research experiments to be conducted with a new two-million-volt X-ray tube at the California Institute of Technology, it was revealed at the Association conference.

Scientists at the California Institute of Technology are now working out the design of the new giant tube which will be housed in the radiation laboratory now nearing completion. Before applying to the study of cancer results being obtained with the two six-hundred-thousand-volt X-ray tubes now in operation, and the new tube, largest in the world giving a continuous ray, physicists, medical men, and biologists will study ray effects upon living cells to determine the general effects of these rays upon living organisms. This preliminary work, it was stated, must precede the actual medical applications in order to insure that harmful effects do not accompany beneficial effects.

While one patient has been treated with one of the six-hundred-thousand-volt tubes, members of the medical board in charge of therapeutic research are watching the results with conservatism, and determination of the results are due some time in the future, it was said. Nothing is expected soon, however.

Several scientists reporting revealed a pessimism toward the value of X-rays in effecting a cancer cure. However, they declared something of extreme value in combating the disease may come from further study of high-voltage X-rays.

Artificial Germ-Fighting Fluids May Replace Natural Products

There is hope that eventually artificial specific protective substances superior to those formed during natural convalescence from disease may be produced

in the chemical laboratory and may become the main therapeutic instruments in the prevention and treatment of microbic infections, DR. W. H. MANWARING of Stanford University told the Association. He explained that numerous specific antitoxins and other protective antibodies have already been synthesized in research laboratories, with the possibility that in time such syntheses will be so perfected as to be of clinical value.

Up until five years ago the generally accepted theory of specific bodily defense against disease was that proposed by DR. PAUL EHRLICH, a German, who assumed that a minute sample of a specific chemical defense against each and every microbic infection is preexistent in normal human flesh, together with a physiological mechanism for its emergency increase in times of specific need. Dr. Manwaring and DR. A. P. LOCKE of Chicago, working independently, discovered that many new, previously non-existent specific biochemical defenses are synthesized as a result of interaction between infections and tissues of the body. This offers the hope of making new disease-fighting agents in the laboratory.—*Science Service*

RUMFORD MEDAL AWARDED DR. KARL T. COMPTON

PRESIDENT KARL T. COMPTON of the Massachusetts Institute of Technology has been awarded the Rumford medal by the American Academy of Arts and Sciences at Cambridge, Massachusetts, in recognition of his researches upon electrons and light waves. The fund providing the medal was established in 1796 by BENJAMIN THOMPSON, native of Massachusetts, the physicist who later founded the Royal Institution of Great Britain and became COUNT RUMFORD of the Holy Roman Empire.—*Science Service*

HOWARD, FOE OF INSECTS, GETS CAPPER AWARD

For distinguished service in leading the army of science against the armies of insects that threaten man's crops, his forests, his house, and his health, DR. L. O. HOWARD, former chief of the Bureau of Entomology, U. S. Department of Agriculture, has been designated to receive the Capper award for 1931. This award consists of a gold medal and a cash purse of five thousand dollars. It was founded by SEN. ARTHUR CAPPER of Kansas and is given each year to a scientist who has made notable contributions to the progress of agriculture. Last year's Capper prizeman [see J. CHEM. EDUC., **7**, 3002 (Dec., 1931)] was DR. S. M. BABCOCK of the University of Wisconsin, whose inventions and discoveries revolutionized the dairy industry.—*Science Service*

NEW AUTO AND PLANE FUEL PROOF AGAINST DROPPED MATCHES

A safety fuel for automobiles and airplanes that is as incombustible as Diesel oil and yet as powerful and as productive of engine performance as good aviation gasoline was demonstrated recently at Langley Field, Virginia, before the sixth annual aircraft engineering research conference of the National Advisory Committee for Aeronautics.

The new liquid is being tested at the Langley Memorial Aeronautical Laboratory in a special single-cylinder engine. This new fuel, produced by one of the leading oil companies, by means of the new process of hydrogenation, has such a low flash point that a lighted match can be tossed into it without starting a fire.

This safety fuel is expected to be important in preventing fires that now follow immediately upon crashes of gasoline-engined airplanes. It is not yet on the market.

To use the new kind of fuel it is necessary to replace the conventional carburetor with an injection pump, but the explosive mixture within the engine cylinder is fired by electrical ignition rather than by compression as in the Diesel engine. With this new development it seems probable that the problem of pro-

viding future airplanes with less dangerous fuel may be met by an adaptation of present internal combustion engines rather than a complete change to the Diesel type.

The new fuel is yellow in color, contains less sulfur, and does not gum as readily as ordinary gasoline.—*Science Service*

ROCKS YIELD SECRETS AFTER ACID TREATMENT

Rocks that cannot be told apart as they are dug out of the ground can be made to disclose their ages and geological kinships by dissolving away most of their substance with hydrochloric acid and examining what is left under a low-power microscope. This method of geological analysis by insoluble residues has been developed by H. S. MCQUEEN of the Missouri Bureau of Geology and Mines, working under the direction of DR. H. A. BUEHLER, State Geologist.

The development of the method was brought about by the presence of quantities of limestone rock from deep wells and other borings. All the samples looked pretty much alike, though it was known that they must be of very different natures and geologic ages. The masking similarity was due to the presence of the limestone matrix, itself in which there were none of the fossil casts that are the usual dating tags which the geologist commonly uses in identifying his finds. Following hints given by earlier workers on the same problem, Mr. McQueen undertook to get rid of the featureless limy matrix by dissolving it in hydrochloric acid, so that he might concentrate his study on the bits of stuff buried in it that are not soluble in the acid.

The method has worked to perfection, he reports. Each type of limestone, indistinguishable to ordinary examination, yields an insoluble residue of particles that is absolutely characteristic for that particular type and unlike the residues of other types. One limestone will have fine sand particles in it, another will contain coarser sand particles of a different color, or perhaps bits of shale, chert, or tiny round pebbles known as oolites, or minute fossil shells or casts.

A peculiar type of particles, whose existence has never before been reported, was found in some of the dolomites. These are thin walls of silica that have been built up around dolomite crystals, and when the latter are dissolved out by the acid a spongy or lace-like mass which shows the cast of the dolomite remains. Since these casts have the characteristic shape of such crystals, Mr. McQueen has given them the name "dolocasts." Dolomites from different beds have yielded different types of dolocasts upon treatment with acid, and these have helped in their identification.

Mr. McQueen has found his method of value in guiding various kinds of economic enterprises dependent on geological knowledge, such as mining, oil-seeking, and deep drilling for water. He has also run cross-section lines in several directions through the state of Missouri, adding materially to the general geological knowledge of the region.—*Science Service*

100 PER CENT EFFICIENT LIGHT MADE BUT NOT FOR USE

An electric lamp converting current into light completely without producing heat at the same time has been operated in a laboratory experiment by DR. M. PIRANI, director of the Society for the Study of Electric Lighting of Berlin. The new tube is not suitable, however, for domestic or industrial lighting.

The invention of a "cold light" that would avoid wasting 80 to 90% of the current as heat, as in the ordinary lamp, has been the goal of physicists and engineers for years. Dr. Pirani's new light, however, is actually heated by a furnace on the outside.

The tube is a modification of the gas discharge tubes used by neon lights in advertising and recently brought to a 30% efficiency by Dr. Pirani. He now finds that if the losses due to the higher

temperature of the discharge tube are taken care of by a separate source of energy, that 370 lumens or light units can be obtained per watt of electricity. This represents a completely heatless conversion of electricity into light energy.

The current is carried by sodium vapor at low pressure and is bright yellow in color. The discovery is only of theoretical importance at present.—*Science Service*

NEW COLOR MOVIES USE TINY COLORED SQUARES

Tiny colored squares, each a seven hundred and fiftieth of an inch on a side, in orange, green, and blue-violet, make possible the latest method of color movies. The new process, known as the Spicer-Dufay process, after its originators, was demonstrated recently to members of the Royal Society. In a report to *Nature*, DR. T. THORNE BAKER comments on the faithfulness with which colors are reproduced.

Though novel in its application to the cinema, the system of using colored squares, through which the picture is exposed, is quite old in still photography. Before the war such a process was used commercially. This was known as the Paget process, and the colored squares were made on a screen that was placed in front of the plate when it was exposed. The colored squares were so small that they could only be seen with a microscope. With the naked eye, the screen appeared of a uniform grayish color. The exposed plate, after development, showed a similar arrangement of squares, though uncolored, when viewed with a microscope. One square, on the negative, would be a record of the blues in that part of the picture, the one next to it, perhaps, of the red, and the one below it of the greens. From this negative, a transparent positive picture was made on another plate. A screen, similar to that through which the picture was taken, was then carefully adjusted over this positive, and a reproduction of the original scene, in full color, was the result.

In the Spicer-Dufay process, a similar method is applied to the movies, and a very ingenious system is used to prepare the colored screen, which is placed right on the film. Starting out with a base of cellulose acetate, or non-inflammable film, one side is dyed green all over. Then it is run through a special printing press, which prints on the green surface a series of parallel black lines, 375 to the inch, with equal clear spaces between. The film is then run through a bleaching bath, which dissolves out the green color in the intervening clear spaces; and then through a bath of orange dye to fill them in again. Next is a treatment with revolving brushes in tanks of benzol to remove the inked lines. They have protected the green dye beneath them, so the result is a series of alternate orange and green lines, 375 of each to the inch. Then ink lines are printed over the film at right angles to the first and, after bleaching, a blue-violet dye is applied, and when the ink is removed again, minute areas of all three colors cover the film.

After protecting layers are laid over the mosaic of color, a fast photographic emulsion, sensitive to all colors, is applied, and the film is ready for use. It is exposed in the camera, which requires no special attachments, and developed. But instead of making a print in the usual manner from a negative, the original film is "reversed" and converted into a positive itself. As the colored squares are still in the same relative position with respect to the negative as when exposed, a spot of the film that was exposed to green light appears green. This is because the film is black behind the orange and blue-violet square, so only green light can get through. The same thing is true of other colors.

Though this reversed negative is now capable of being projected on the screen, it is necessary to make copies if the method is to be practicable. Ordinarily, to copy this film directly on another unexposed film would result in unpleasant

"moire" effects, such as can be seen when two screens are held together against a light background. However, this has been avoided, says Dr. Baker, using a lens in printing. This lens has very slight depth of focus, which means that it will focus sharply in one plane, while a point very slightly nearer to or farther from the lens will be out of focus. Light passes through the original film, and the lens forms the picture on a strip of unexposed film, the two films moving along together. The actual picture, made of grains of silver, is focused sharply, but the colored mosaic, only a twenty-five hundredth of an inch farther back, is diffused, and moire effects thus avoided. In making the copy, as in making the original film, the light passes through the film base before reaching the sensitive emulsion, unlike ordinary still or movie films, in which the film faces away from the lens.

The process can also be used for sound films, as it is possible to leave an uncolored strip a tenth of an inch wide along the side to take the sound track.—*Science Service*

THE 36TH GENERAL MEETING OF THE GERMAN BUNSEN SOCIETY FOR APPLIED PHYSICAL CHEMISTRY HELD IN VIENNA, MAY 25–28, 1931

This year's General Meeting of the German Bunsen Society in Vienna was not only an event of scientific importance but also a vigorous demonstration in favor of coöperation between Germany and Austria, which, if freed from tariff barriers, could work together in the greatest harmony. In the opening session which was introduced by a speech of PRESIDENT MIKLAS this point of view was especially forcibly expressed as being particularly important with reference to the sphere of physical chemistry with its combinations of theory and practice.

This year the discussion centered round the problems of metallurgy, with particular reference to light metals. The first chairman of the Bunsen Society, DIREKTOR DR. SPECKETER of Frankfurt-Griesheim, emphasized the increasing importance of aluminum, magnesium, and their alloys. He showed in a few words how the aluminum production of the world had risen in the post-war period, and pointed out that in all transport operations the desire to reduce ballast leads to the use of aluminum and its alloys with specific weights only about one-third that of iron. Similarly the other papers dealt with various metallurgical problems and that of PROFESSOR TAMMANN of Göttingen, the well-known authority on metallurgical problems who celebrated his 70th birthday during the meeting, was especially well received. The professor of theoretical physics at the Technical High School in Berlin, R. BECKER, showed in his concluding lecture that it is possible, by means of wave mechanics and quantum mechanics, to explain certain electric and magnetic properties of metals which have so far appeared contradictory, and he was able, thanks to his lucid exposition, to throw open this very difficult and abstract field of thought to a very wide public.

Although the program included sixty individual lectures, provision was also made for the entertainment of the participants. A great banquet was held in the banqueting hall of the Hofburg at which visitors were able to meet, and the reception by the Ministers of education, of trade, and of transport introduced them to the apartments of the famous Schloss Schönbrunn. The splendid Whitsun weather favored excursions of all sorts into the surrounding country, and finally a special performance at the Opera concluded the meeting.

THE 5TH GENERAL MEETING OF THE DECHEMA, VIENNA, MAY 28–30, 1931

The Dechema, German Society for chemical apparatus, held its general meeting in Vienna at the same time as

did the Verein deutscher Chemiker, German Chemists' Society. The scientific proceedings were exceptionally well attended and the papers which were communicated on the important subject, "The Separation of Liquids and Solids," aroused wide and profound interest. Even the tropical heat did not prevent the occurrence of lively discussions after the papers. In all, twelve papers were communicated dealing with filtration in the laboratory and on the technical scale, the latter being naturally in the majority. We are informed that this interesting series of lectures will shortly be published as volume form of the Dechema Monographs.

On Saturday, May 30th, those taking part in the general meeting were able to visit the almost completed new Institute of Chemical Technology of inorganic compounds, a part of the Vienna Technical High School. This Institute provides an almost ideal solution of the problem of enabling the students to work with apparatus which corresponds to factory-scale conditions.

The success of this year's General Meeting of the Dechema has once more indicated in a very gratifying way how the efforts of this relatively young scientific organization are receiving the unstinted praise and recognition of all those concerned.

The Alcohol Family. Ethyl alcohol is still first in gallons of annual output of the many alcohols known, but some of these associates now tend to become rivals for certain uses.

Back in the time of the last business depression a decade ago, ethyl alcohol from grain or molasses and methyl or wood alcohol held the field almost undisputed. At that time butyl alcohol or butanol, made by fermentation from corn, was starting upon the initial stages of its great commercial development which, from a production of 2,000,000 pounds in 1921, reached 67,500,000 pounds in 1929, and probably contributed more than any other chemical factor to the rise of the modern automobile lacquer industry.

In 1926 came the first of the synthetic alcohols, methyl alcohol or methanol, which was produced by the union of carbon monoxide and hydrogen. It is chemically identical with wood alcohol. As a result of this new synthesis, the wood distillation industry has declined, and the annual production of synthetic methanol has reached approximately 7,000,000 gallons, the price per gallon falling in 1930 for the first time in history below the price of denatured ethyl alcohol.

But the synthetic chemist did not stop with this lowest member of the alcohol series. In 1929 the production of ethyl alcohol was begun by a process starting from natural gas, and in 1930 one of our great chemical corporations announced the manufacture, by a method analogous to that employed in making synthetic methanol, of a mixture of alcohols higher than ethyl. Meanwhile, the refinery gases and cracking gases of the petroleum industry were being made to yield a whole series of alcohols which bid fair to take their places in industry alongside products of older methods.

The result of these developments is that in addition to fermentation and wood distillation, carbon monoxide and hydrogen, natural gas and the by-products of the petroleum industry are all being made to yield alcohols, so that each product made by a given process may have to compete both with an identical product made by one or more different processes and with products, possibly several of them, not chemically identical, but sufficiently similar to "do the same work." The next few years probably hold many readjustments in store for alcohol makers, and alcohol users, as well as for investors in the industries concerned.—*Ind. Bull., Arthur D. Little, Inc.*

Recent Books

Smith's Introductory College Chemistry. JAMES KENDALL, F.R.S., Professor of Chemistry in the University of Edinburgh; formerly Professor of Chemistry at Columbia and New York Universities. The Century Co., New York City, 1931. xii + 555 pp. 16 illus. + 142 figs. 13.5 × 20.5 cm. $3.25.

This text presents the fundamental material of a standard course in general chemistry for colleges and embraces forty-four chapters chosen along the lines of the other familiar texts by the same author. With very few exceptions, the order of presentation of the subject matter follows closely that of the 1929 edition of the "College Chemistry," and the subject matter has been modified only where it seems desirable for the sake of brevity without sacrificing important phases in the orderly development of the subject.

While the text follows closely the original style of Alexander Smith, an outstanding example of choice teaching, one may venture to ask if perhaps the beauty of the Smith style, the precise English employed, and the close distinctions and faultless logic, may, as a practical matter, not be ill-advised as a tool in the hands of the typical American college student. This text in the hands of a very human teacher possessing a sense of values, using such informalities of expression and illustration, as are not permissible in written English, would make up for the loss of effectiveness of a textbook of real literary quality such as the one presently under consideration. The writer is not unaware of the success of the Smith texts and of their extensive adoption under the editorship of Professor Kendall, but having had several years of experience actively teaching the "College Chemistry," he has often thoughtfully considered the wisdom of attempting to present the material normally considered necessary in such a course in a vocabulary and literary style somewhat removed from the appreciation of the personnel of the usual college freshman class. The opposite has been tried in textbook writing with almost complete failure, and of the two styles of presentation the writer distinctly prefers the Smith slant.

Some of the outstanding features of this text are: a very arresting introduction; an unusually clear and sound presentation of the atomic theory woven around the newer conceptions of the atom and molecule; an early consideration of symbols and equations as an integral part of the development of the subject; a well-arranged chapter in which the molecular weight concepts are very clearly developed and a final justification of atomic weights; a copious series of well-selected illustrations and drawings; a satisfactory account of the Arrhenius theory of ionization with its subsequent ramifications well utilized; an exceptionally interesting treatment of radioactivity and atomic structure; a substitution of chapters on Plant Life, Plant Growth, Plant Products, Animal Life and Products, for the traditional topics of organic chemistry commonly embraced in the usual course in general chemistry.

At the close of the chapters will be found a series of well-selected problems and provocative questions. The text closes with an appendix of useful data.

In the judgment of the writer, this text is hardly serviceable for courses based on a year of high-school chemistry, and the author does not make this claim, but for those who have not had such background it should prove an adequate preparation for subsequent courses in the subject as well as a stimulating course of practical value for the general student. While there are some attractive

texts available in the field of "Pandemic Chemistry," it occurs to the writer that such a work as this admirably meets the need and is strongly recommended. Chemistry can be made too popular but in this text one finds a well-blended account of the science both from a practical and theoretical point of view. It should fill an important niche in textbook literature.

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TULANE UNIVERSITY OF LOUISIANA
NEW ORLEANS

Radiations from Radioactive Substances. SIR ERNEST RUTHERFORD, O.M., D.Sc., Ph.D., LL.D., F.R.S., Cavendish Professor of Experimental Physics in the University of Cambridge; JAMES CHADWICK, Ph.D., F.R.S., Fellow of Gonville and Caius College, Cambridge; and C. D. ELLIS, Ph.D., F.R.S., Fellow of Trinity College, Cambridge. At The University Press, Cambridge, England; The Macmillan Co., New York City, 1930. xi + 588 pp. 12 plates + 140 figs. 16 × 23.5 cm. $6.50.

In the preface Rutherford states that since the publication of his book entitled "Radioactive Substances and Their Radiations" (1912) there has been a very rapid growth of our knowledge of the transformation of radioactive substances and of the radiations which accompany these transformations. Many thousands of new papers dealing with various aspects of the subject have been published. With the exception of a few outstanding problems, the wonderful series of transformations of uranium, thorium, and actinium are now well understood, and attention today tends to be more and more concentrated on the study of the α, β, and γ rays which accompany the transformations and of the effects produced by these radiations in their passage through matter. The great value of this information lies in its bearing on the structure of the nucleus of the atom and of the energy changes involved in its transformation. Moreover, evidence is accumulating that the artificial disintegration of the nuclei of a number of the ordinary elements in bombardment by swift α particles may in some cases build up a nucleus of greater mass by capture of the colliding α particle. For these reasons this book has been confined mainly to an account of the radiations from active matter and their application to physical problems. The book gives a concise and connected account of our knowledge of the radiations from radioactive substances, and of the bearing of the results on the problem of the structure of the nucleus.

This objective the authors have accomplished in masterly form. In reading this book one becomes impressed with the magnitude, great significance, and importance of the pioneer researches conducted for so many years in the Cavendish Laboratory on the nature of the changes in the nucleus of the atom and of the radiations emitted during the transformation.

Incorporated in this account are the experimental researches in this field which have been vigorously conducted in other laboratories. The book thus constitutes a full, coördinated account with discussion of the advances in this field of knowledge. The authors do not fail to point out where the facts already obtained fall short in finding adequate interpretation.

After a brief account of the theory of successive transformations in radioactive changes, Chapter I, follow Chapters II–VII, pp. 38–190, dealing with the nature and properties of the α particle and the great variety of effects which are observed in its passage through matter.

In Chapters VIII–XII, pp. 191–384, are considered the scattering of α and β particles, and the collision of α particles with light atoms. Here are discussed the occasional large deflections suffered by an α particle in passing close to a nucleus and the information which has been obtained in this way on the nuclear structure of the atom and the nature and variation of the forces close to the nucleus.

Then follows an account of the experimental observations on the artificial transformation of certain light elements resulting from the close collisions of the α particle with the atomic nucleus. Definite proof is given that the nuclei of some of the lighter elements can be transformed by the action of external agencies.

The dimensions of radioactive nuclei, and the theory of their structure are considered in Chapter XI. The complex emission of β rays and the important part played by γ rays in disintegration are described in Chapter XII. Then follows a chapter on the passage of β particles through matter, pointing out the difficulties encountered in this study, and the progress made. The experimental methods for measuring the absorption and scattering of rays have resulted in measuring the wave length of the stronger γ rays and to the determination of their relative intensities.

Chapters XVI–XVIII give briefly an account of our knowledge of the ultrapenetrating γ rays, known as cosmic rays, observed in our atmosphere, and of the radioactivity of matter in general with special reference to the type of radioactivity shown by potassium and rubidium. Pp. 517–536 summarize the state of our knowledge of the mass and structure of the nuclei of the common elements and their relation to the radioactive elements. In the closing chapter, "Miscellaneous," a few pages are given to each of the following topics: the counting of scintillations; the chemical properties of the radioactive elements; the preparation of sources of radon, radium-active deposit, and thorium-active deposit; the measurement of quantities of radium; and International Radium Standard.

A short appendix gives the values for the fundamental constants which the authors have used in the numerical calculations in the book; a list of chemical elements with their atomic numbers and atomic weights; a periodic table of elements; and a supplementary note on artificial disintegration by α particles. A table of isotopes is found on p. 522 in the chapter on Atomic Nuclei.

This book will be a home and laboratory companion for students of radioactivity and those engaged in research work in this field.

HERMAN SCHLUNDT

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COLUMBIA, MISSOURI

Radioelements and Isotopes: Chemical Forces and Optical Properties of Substances. KASIMIR FAJANS, University of Munich. McGraw-Hill Book Co., Inc., New York City, 1931. x + 125 pp. 14.75 × 22.75 cm. $2.50.

This, the ninth volume of the George F. Baker Non-Resident Lectureship in Chemistry at Cornell University, is a worthy continuation of the series of lectures which have been given by outstanding European chemists and physicists during the past five years. The introductory lecture is devoted to the "Development of Views Regarding the Nature of Chemical Forces." The remainder of the book is divided into two parts of unequal length. The first part consisting of a single chapter deals with the origin of the actinium series and with the stability of isotopes considered from a radioactive standpoint, though not limited to radioactive isotopes. The second part treats chemical forces and optical properties, a subject to which the author has recently directed much attention. It is divided into seven chapters dealing with the following subjects: Outline of Atomic and Crystal Structures; The Ideal Ionic Linkage; General Remarks on the Deformability of Ions; Change of the Refractivities of Ions in Molecules and Crystals; Transitions between Ideal Ionic Linkage and Non-Polar Linkage; Adsorption of Ions on Saltlike Crystals with Applications to Volumetric Analysis; and Photochemical Applications of Ion Adsorption.

S. C. LIND

UNIVERSITY OF MINNESOTA
MINNEAPOLIS, MINN.

Essentials of Quantitative Chemical Analysis. A Laboratory Manual for Colleges. WILFRED W. SCOTT, Sc.D., Professor of Chemistry, University of Southern California. The Chemical Publishing Co., Easton, Penna., 1931. viii + 219 pp. 18 figs. 15 × 23 cm. $2.75.

This is the second edition of the author's book, the first edition of which was published in 1926 under the title "Inorganic Quantitative Chemical Analysis." The text has been revised so as to include more of the fundamental chemical theory underlying the procedures involved in quantitative methods. Considerable new material has also been added. The book is designed for students of college grade who are beginning the study of quantitative chemical analysis and may be looking forward to either chemical engineering or medicine and pharmacy as their life work.

The reviewer is glad to note that the author of this book chooses to introduce quantitative analysis by beginning with gravimetric rather than volumetric methods. He believes this to be the logical as well as the correct psychological order, contrary to the present-day tendency to begin the subject with volumetric methods.

Following a brief but clear discussion of general procedures used in gravimetric analysis there is a very good selection of determinations beginning with the simpler and progressing to the somewhat more complex, keeping, however, entirely within the scope of the beginner's field.

The second part of the book deals with volumetric methods grouped according to the generally accepted order as follows: neutralization, oxidation and reduction, iodimetric, volumetric precipitation, and colorimetric methods. Following the section on volumetric analysis are several short chapters dealing briefly with some of the newer and more specialized methods of analysis.

The questions and problems have been placed together in a section at the end of the book instead of being appended to each chapter separately, so as to make revisions with the main object of changing the questions and problems easier.

The text of the procedures has the fundamental virtue of being clear and brief enough to be comprehensible to the average student. At the same time enough theoretical discussion has been introduced to stimulate the student to a desire to investigate the subject further. In the opinion of the reviewer this book, supplemented by recitations and by discussions of the theoretical chemistry involved, is very well adapted to its purpose as a laboratory guide in quantitative chemical analysis for college students.

H. W. BRUBAKER

KANSAS STATE COLLEGE
MANHATTAN, KANSAS

Handbook of Chemical Microscopy. Vol. II. Chemical Methods and Inorganic Qualitative Analysis. ÉMILE MONNIN CHAMOT, B.S., Ph.D., Professor of Chemical Microscopy and Sanitary Chemistry, Cornell University; and CLYDE WALTER MASON, A.B., Ph.D., Assistant Professor of Chemical Microscopy, Cornell University. John Wiley & Sons, Inc., New York City, 1931. ix + 411 pp. 818 figs. 15 × 23 cm. $4.50.

This is the second volume of a two-volume publication, based on the senior author's "Elementary Chemical Microscopy" (1921). The first volume was concerned with the principles and use of microscopes and accessories, also the description of physical methods for the study of chemical problems. The second volume is primarily a handbook of microchemical qualitative tests, together with descriptive methods of technic and manipulation. The authors make no claim to originality except with respect to a small number of the methods presented. Like any work on analytical chemistry, it is largely a compilation of tests already well known to chemists. It is the unique method of presentation and systematic

arrangement of the tests which attract the reader.

Chapter I describes manipulative methods for handling small amounts of materials. Such subjects as solubility, decantation, filtration, sublimation, distillation, etc., are taken up and technic and apparatus described. Chapter II suggests methods of applying reagents, so that dependable and diagnostic reaction products can be reproduced under definite and controllable conditions. The experienced microanalyst appreciates how important this is. Chapters III to X, inclusive, describe in detail tests for the various elements, these being taken up according to the grouping in the Periodic Classification. Chapter XI in 76 pages gives a comprehensive and methodically arranged scheme for the identification of the anion of a salt. The common organic acids, such as acetates, oxalates, and tartrates are also discussed. Chapter XII deals with special reagents which give reactions with a number of elements. The reagents which have been found useful in this connection are hexamethylenetetramine, potassium ethyldithiocarbonate and zinc sulfide fibers. The separation of metals based upon differences in electrical potentials is also referred to. Chapter XIII presents a practical working scheme for handling material of unknown composition. The Appendix furnishes useful information for the preparation of special reagents, a list of reference works on microanalysis, etc.

There are several interesting features about this work which should appeal to the working analyst and also to the teacher of microscopical qualitative analysis. The grouping of the text descriptions is very convenient for a working handbook and together with the well-arranged index affords ready reference. The descriptions are not too brief but replete with notes drawn from the authors' experience with those tests in their own laboratories. The pointed suggestions to protect the analyst from pitfalls due to erroneous interpretations are timely, since all too often a good microchemical test has suffered due to careless attention to directions and ultimate misinterpretations of results. The illustrations of the crystalline precipitates, the end-products of reactions taking place under the microscope, are exceptionally good and are produced on paper well chosen to bring out the details. The numerous references to the literature throughout the text are most valuable to the research worker.

From an educational standpoint such a handbook (in conjunction with Vol. I) could not but be most useful to the teacher of chemistry. Developing the ability to observe and interpret phenomena under the microscope are valuable to the beginner in science and, of course, quite essential in chemical microscopy. It so frequently happens that the laboratory worker is confronted by such meager portions of material for identifying substances by the usual methods that his resourcefulness is severely taxed, unless, perchance, he has been fortified somewhere in his chemical training, by an acquaintance with such valuable short cuts as microchemical tests. This handbook of Chamot and Mason presents in a logical and teachable form the results of years of experience in this specialized field of chemistry. By following the experiments scattered through this text the student cannot fail to recognize diagnostic differences on a small scale and with practice be able to draw trustworthy conclusions from the crystal pictures he sees under the microscope.

GEO. L. KEENAN

MICROANALYTICAL LABORATORY
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Elementary Textile Microscopy, JOHN H. SKINKLE, S.B., Instructor in Textile Chemistry and Microscopy, Lowell Textile Institute. Foreword by LOUIS A. OLNEY, D.Sc., Professor of Chemistry and Dyeing, Lowell Textile Institute. Directing Editor, *American Dyestuff Reporter*. Howes Publishing

Company, 440 Fourth Avenue, New York City, 1930. 144 pp. 95 figs. 14 × 20 cm. $2.50.

The author states in the preface, "It (the book) is intended as a combination text and laboratory manual for the author's classes in microscopy at the Lowell Textile Institute but it is also intended to be of aid to the independent worker in the industry who may or may not have had a college education or the equivalent in optics. In brief the object of this book is to collect in one volume enough of the fundamentals as to apparatus, methods, and data on the fibers to introduce the reader to the large subject of Textile Microscopy."

The book is divided into seven parts. Part I takes up apparatus describing equipment which could be used in a textile microscopy laboratory. Part II deals with methods used in making longitudinal mounts and cross-sections. It discusses briefly micrometry and microchemical reactions. The author seems to lose himself, in the Shaw fashion, in his discussion of longitudinal mounts. The description of the cutting of cross-sections is very good. Part III is called Identifications. The first part of this section is devoted to the microscopic identification of starches. The second part takes up the microscopic identification of textile fibers. On first reading, it appears that undue emphasis was placed on identification of starches but when it was remembered that the book was written in a cotton manufacturing locality and the importance of starch as a cotton filler, the reason for the introduction of this subject was understood. There are a number of photomicrographs in this chapter, several particularly clear ones of cross-sections of various rayons. Part IV discusses Low-Power Microscopy in quite an introductory way but with some interesting photomicrographs. Part V takes up Photomicrography. This seems in the opinion of the reviewer to be unusually well written. It very simply and clearly describes types of apparatus, photomicrographic manipulation, exposure time, color photography, etc. Part VI gives a list and description of a variety of good experiments which could be covered in a very short time and give some knowledge or could be expanded to give a very thorough knowledge of the field of textile microscopy. Part VII includes various formulas, descriptions of the microscopic appearance of textile fibers, and bibliography.

The text contains a large number of illustrations considering the total number of pages. The illustrations are on the whole very good considering the difficulty of photographing the subject matter and printing.

In the opinion of the reviewer, the author has succeeded admirably in carrying out the primary purpose of the book. Its value from the standpoint of chemical education is difficult to estimate as the author places chemistry in the background and emphasizes simplicity. This seems to be necessary in order to fulfil the purpose of the book.

This book would be helpful as a reference for those beginning the study of textile microscopy or to those working in this field in the industries. It would be an up-to-date and worthwhile addition to the library of any one interested in Textile Microscopy.

MARY L. WILLARD
THE PENNSYLVANIA STATE COLLEGE
STATE COLLEGE, PENNA.

Essentials of Organic and Biological Chemistry. E. WERTHEIM, Ph.D., Professor of Chemistry, University of Arkansas. The Chemical Publishing Co., Easton, Pa., 1931. vi + 175 pp. 7 figs. 15 × 23 cm. $2.50.

This volume was apparently written for a very special group and will be of value only to that group. It is an ambitious undertaking to attempt to cover in 175 fairly open printed pages even the "essentials" of both organic and biological chemistry.

The volume is designed as a text for a combined course in organic and biological

chemistry, the course being "for one semester (18 weeks) with two periods a week for lecture and recitation and two laboratory periods." The first eight weeks are devoted to a consideration of the aliphatic compounds, with the exception of carbohydrates and proteins, which are included in the second eight weeks along with other biochemical compounds.

The 175 pages are divided into twenty chapters, introduction, saturated hydrocarbons, ethylene series, acetylene series, halogen derivatives, alcohols and ethers, aldehydes and ketones, acids and their derivatives, polybasic acids and urea, amines, optical activity, carbohydrates, aromatic compounds, proteins, metabolism, nutrition, dietary necessities, and foods and beverages. Appended to each chapter is a list of questions to guide the student in preparing for the inevitable examinations.

The chapter on carbohydrates may be taken as a sample. It covers a total of 12 pages, 5 pages of which are devoted to the monosaccharides, less than 2 pages to the disaccharides and 3 pages to the polysaccharides. The only formulas which are given are the straight-chain structural formulas for glucose, "levulose," and galactose. (The spacial configuration of galactose is in error, the formula labeled "galactose" is in reality *d*-idose.) The ring formula and mutarotation are not mentioned. Starch is given the "proposed formula" $C_{216}H_{360}O_{180}$ or $(C_6H_{10}O_5)_{36}$.

The reviewer regrets that it is necessary to offer such abbreviated chemical courses in certain of our universities. The only justification seems to lie in the supposition that a little information is better than no information at all, but to designate such a course a "university course" certainly justifies in part the criticisms which Abraham Flexner has recently directed at the American university system. As a college text it is too elementary, and too brief to be recommended. It might serve a very useful purpose as a high-school text for those students who wish to follow up their year of "chemistry" with a second year of the same subject.

ROSS AIKEN GORTNER

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ST. PAUL, MINN.

Laboratory Manual of Physiological Chemistry. MEYER BODANSKY, Ph.D., Director of Laboratories, John Sealy Hospital, Galveston, and Professor of Pathological Chemistry, University of Texas; and MARION FAY, Ph.D., Associate Professor of Biological Chemistry, School of Medicine, University of Texas. Second edition, revised. John Wiley & Sons, Inc., New York City, 1931. xi + 260 pp. 9 figs. 15 × 23 cm. $2.00.

This book was written very obviously for students in medical courses in physiological chemistry; it contains no reference to methods applied to plant biochemistry although the field of animal biochemistry is very well covered. There are chapters on colloids, the proximate principles, tissues, digestion, milk, blood, and urine. The first chapter deals with the place of quantitative chemical analysis in physiological chemistry; it is brief and to the point and provides an excellent point of departure for the motivation of the laboratory work. Throughout the book there is evidence of sound pedagogical balance; the qualitative experiments are given in a manner indicating that they have been tried out and found satisfactory. The directions for the quantitative methods are given much as originally published and, while sample calculations are occasionally given, the student is required to establish his own formulas for estimating the results. The selection of methods has been confined to those found satisfactory by the authors, with emphasis upon the more recent ones. In no sense is the book a catalog of currently available biochemical methods. There is, unfortunately, little attention given to the quantitative evaluation of the enzyme potency of the digestive

juices. It is an easy book to use because of the effective use of footnotes containing references to the literature, supplementary information and comments by the authors. This volume constitutes a worthwhile contribution to this special branch of chemical education.

ARTHUR H. SMITH

YALE UNIVERSITY
NEW HAVEN, CONN.

The Terpenes. Vol. I. The Simpler Acyclic and Monocyclic Terpenes and Their Derivatives. J. L. SIMONSEN, D.Sc. (Manc.), F.I.C.; Professor of Chemistry, University College of North Wales, Bangor; formerly Professor of Organic Chemistry, Indian Institute of Science, Bangalore. At The University Press, Cambridge, England; The Macmillan Co., New York City, 1931. xv + 420 pp. 14 × 21.5 cm. $8.50.

During the past two decades great progress has been made in our understanding of the chemistry of the terpenes and of their derivatives, but we have lacked, in the English language, any comprehensive and adequate presentation of these advances and of our present knowledge of this important branch of organic chemistry. Dr. Simonsen, himself an outstanding investigator in this field, has undertaken to supply this deficiency, and the volume which has just appeared is to be followed by a second one which will discuss the dicyclic and sesquiterpenes.

The terpenes present in essential oils are considered in Parry's "The Chemistry of Essential Oils" and in Finnemore's "Essential Oils," as they are in the new edition of Gildemeister and Hofmann's "Die aetherische Oele," and in other recent works in languages other than English, where they are presented more from the standpoint of their interest to the perfume and essential oil industry than as a chapter in systematic organic chemistry. Brooks' "The Non-Benzenoid Hydrocarbons," on the other hand, because of its extensive scope, could not devote to the terpenes sufficient space to discuss them in any great detail and no new edition has appeared to bring this part of his monograph up to date.

As noted in the title, this volume covers only the simpler acyclic and monocyclic terpenes and their derivatives, and these are grouped under the following chapter headings: Part I. The Simpler Acyclic Terpenes and Their Derivatives; Chapter I. Hydrocarbons (geraniolene, myrcene, ocimene, etc.), Chapter II. Alcohols (citronellol, geraniol, linalool, etc.), Chapter III. Aldehydes (citronellal and citral), Chapter IV. Ketones (octenone, tagetone, etc.), Chapter V. The Cyclogeraniolenes and Their Derivatives (cyclocitrals, ionones, irone, etc.). Part II. The Monocyclic Terpenes and Their Derivatives; Chapter I. Hydrocarbons (limonene, terpinenes, phellandrenes, etc.), Chapter II. Alcohols (menthols, terpineols, pulegols, etc.), Chapter III. Aldehydes (phellandral, perillaldehyde, etc.), Chapter IV. Ketones (menthones, pulegones, carvones, etc.), Chapter V. Oxides (cineols, pinol, ascaridole). Complete author and subject indexes follow the text. Type and paper are excellent.

In order to restrict the size of the book, the author has, with a few exceptions (sylvestrene, carvenone, terpine hydrate, etc.), limited himself to the ten-carbon terpenes found in nature. A valuable feature is the attention which the author has given to determination of constitutions and methods of synthesis, for this will be of great assistance to all teachers of organic chemistry, as well as to those undertaking research in this difficult but fascinating field.

The subject matter is presented clearly and as concisely as is consistent with intelligibility. For those wishing fuller details, ample references to the original articles are provided. Such troublesome problems as the rearrangements and cyclizations of many of these terpenes, the configurations of the various stereoisomeric menthols, menthones, and menthylamines, the constitution of citronellol,

geraniol, rhodinol, nerol, and the corresponding aldehydes, the dioxide formula for ascaridole, and many others of equal difficulty or perplexity are ably handled.

In the opinion of the reviewer, the author has succeeded admirably in his purpose, and his book should be most welcome to all interested in the organic chemistry of the terpenes.

MARSTON T. BOGERT

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MISCELLANEOUS PUBLICATION

Pyrex Bends, Bulbs, and Seals. A Manual for the Laboratory Technician. W. T. LEVITT. Corning Glass Works, Corning, New York, 1931. 15 pp. 20 × 27.5 cm. Free to instructors.

This booklet has been prepared to aid laboratory workers and instructors in the construction and repairing of special designs of Pyrex apparatus ware. The directions and illustrations are excellent.

Students Influenced by What "Everybody Thinks." One out of three adults will change his opinion on controversial social or ethical matters to what he learns that other people think. But students in high school and college are even more suggestible. More than half of each of these groups were influenced by the group opinion.

These figures were obtained by C. H. Marple, working with Dr. Norman C. Meier at the University of Iowa and reported by them to the Midwestern Psychological Association. They asked 900 persons to express their opinions independently on the various topics, which included matters of general, social, economic, and ethical interest. Three groups were represented, including 300 high-school seniors, 300 college seniors, and 300 representative adults.

After a lapse of one month, the same questions were given again. For 300, representing all three groups, the questions were in their original printed form. For another 300, the questions were marked to show what was the consensus of opinion of 900 persons. For the third group of 300, the questions were marked to show the opinion of experts or authorities.

The opinion of experts was not nearly so influential as that of the group of 900. The changes of opinion among those who saw the expert opinions amounted to 51 per cent for the high-school students, 45 per cent for the college students, and 34 per cent for the adults. The shifting under the influence of group opinion was 64 per cent for the high-school students, 55 per cent for the college people, and 40 per cent for adults. The shifting when the papers were not marked was very small in comparison, ranging from less than 14 per cent for adults to about 17 per cent for the high-school seniors.—*Science Service*

So far as the average brain itself is concerned, I think it would be safe to say that it would be able to meet even extraordinary demands. The trouble with normal persons is not the brain; it is somewhere else. The world is full of men and women whose brains are practically idle. It is estimated that there are perhaps ten billions of cells in the average brain. But there are millions and millions of undeveloped cells and fibers in the brain when old age is reached. Millions of twelve-cylinder brains are hitting on only one cylinder. And in very many of these cases there is no real reason why the brain can not be used to capacity. Every normally healthy brain is capable of doing work far beyond what is usually demanded of it. The best way to develop a brain is to think with a purpose.—DR. LOUIS CASAMAJOR

EDITOR'S OUTLOOK

Francis William Aston, 1877–

IN ASTON we find an example par excellence of that human paradox, the versatile specialist. His scientific fame rests chiefly upon his work in a rather narrowly specialized field. Yet the list of his other activities is nothing short of impressive. For instance, he is fond of lawn tennis and at one time attained such a degree of skill in it that he won many prizes at open tournaments in England, Wales, and Ireland. He has won prizes for swimming, also, and is said to perform very creditably on the golf course. In his early twenties he took up bicycling, touring England and Wales and once covering two hundred miles in twenty-two hours. Knowing as much as we do about his work in the field of physics, we are not surprised that he has a thorough scientific knowledge of the petrol engine, and in 1903 attended the Gordon Bennett race in Ireland on a motorcycle of his own design and construction. Indeed, at the early age of three, he evinced a passionate fondness for all sorts of mechanical toys. He was the third of seven children. The family was musical and, beginning at seven years, he studied first piano, then the violin, and finally the 'cello and is acclaimed as an excellent amateur performer on that difficult instrument. One wonders if T. W. Richards' remark anent 'cellists and scientists was phrased entirely at random. Aston has also exhibited a fondness for travel, especially on the sea. In 1909 he made a trip around the world and among other places visited Honolulu. Here he learned surf-riding and seems fairly convinced that it is one of the best sports in the world. Even his interest in science has not been confined to one field, but has branched off into astronomy in which he achieved sufficient proficiency to join eclipse parties by government invitation, once in 1926 and again in 1929.

Amid so great a profusion of attainments, we are in danger of losing sight of our central interest. Francis William Aston was born at Harborne near Birmingham in 1877, the son of an English metal merchant. In 1891 he was sent to Malvern College and at the time of his departure was in the highest mathematical set, and head of the whole school in chemistry and physics, which upsets the comfortable theory that the truly capable never achieve brilliant school careers. He then went to Mason College, studying under Tilden, Frankland, and Poynting, and about 1895 started to specialize in organic chemistry. His spare moments were spent at the blowpipe, acquiring skill in glassblowing, which later was to become a decisive factor in turning his thoughts toward vacuum research. By reason of economic necessity Aston's systematic scientific training was interrupted for several years, during which time he was engaged in technical fermentation chemistry at a Wolverhampton brewery. But his clarity of purpose survived this interlude. In 1903, awarded a university scholarship, he returned to Mason College and

began serious research on the Crookes dark space, discovering in 1907 a hitherto unobserved "primary" dark space in certain gases. Sir J. J. Thomson, recognizing the promise of this young scientist, offered him a private research assistantship at the Cavendish Laboratory. Beginning in 1910, Aston continued his researches on the dark space and assisted Thomson in his work on positive rays. Awarded the Clerk Maxwell Studentship in 1913, he turned his attention to a study of neon and before the end of the year published results on the partial separation of the isotopes of this non-radioactive element.

Then the war came and as technical assistant at the Royal Aircraft Factory at Farnborough he investigated the action of weather and sunlight on aeroplane dopes and fabrics, and invented a special type of neon tube still used in stroboscopic work.

The war over, he began investigating various methods of positive ray analysis, which research led to the design and construction, at Cambridge in 1919, of that ingenious and exact instrument, the mass spectrograph. The isotopic nature of neon was established beyond doubt; isotopes of chlorine and many other elements were discovered; the Whole Number Rule was enunciated. And it was this work which won for him the Nobel prize in chemistry for 1922, to mention but one of many awards and honors conferred upon him. Over fifty elements were analyzed by the aid of the original mass spectroscope before it was replaced, in 1925, by a more precise one, and retired to the Science Museum at South Kensington. Since 1920, Aston has been a Fellow of Trinity College and during the last ten years has published numerous papers on his mass-spectroscopic investigations of isotopes. In 1927, "a most precise series of measurements on the relative masses of the atoms . . . made it possible to subject to a new test the Einstein formula for the relation between mass and energy, namely, $E = mc^2$."

Aston is primarily an experimenter of unusual powers and judgment. His general outlook in science is inclined to be non-mathematical, employing models wherever possible. He has never done much teaching except by lectures, and associates more with the senior members of the university than with the undergraduates.

The phenomenon of isotopy originally discovered by the investigators of radioactive elements, and first investigated in non-radioactive ones by Thomson, he carried to an admirable conclusion. Those engaged in research, who see their length of years threaten the completion of the all-engrossing business in hand must be grateful enough for students who catch their enthusiasm and carry forward their work. But few are fortunate enough to have it taken up and prosecuted so brilliantly and so well.

The JOURNAL OF CHEMICAL EDUCATION *gratefully acknowledges the courtesy of* DR. RALPH E. OESPER, *of the University of Cincinnati, for the*

accompanying photograph of Professor Aston, and of SIR ERNEST RUTHERFORD, *of the Cavendish Laboratory of Cambridge,* DR. F. G. DONNAN, *of the University of London, and* DR. J. A. CROWTHER, *of the University of Reading, for much of the material on which this biographical sketch is based.*

Chemistry and Agriculture

THOSE who have given any serious thought to the present state of agriculture are aware that the farmer is involved in a phase of economic evolution as irresistible as the tides of the ocean. The industrialization of agriculture (at least in so far as staples are concerned) is not only an inevitable development; it is already an accomplished fact. Wheat and cotton are now being produced at a fair profit for prices which signify absolute ruin to the farmer of the traditional type. No political nostrums, no tariff-tinkering, no government subsidies can touch the root of the farmer's present griefs. He is being "liquidated" as effectually and as inevitably as the hand-craftsman of an earlier age.

There is another aspect of the agricultural situation, however, which apparently has not been so widely recognized. Dr. William J. Hale in an address delivered at the annual meeting of the Manufacturing Chemist's Association, and since published in *Chemical Markets*, shed considerable light on the subject when he said, "Chemistry decrees that organic chemical mixtures—agricultural staples if you wish—never again can sell for more than the sum of the chemical values of their several components." Ninety-nine per cent alpha cellulose in the form of cotton cannot hope to compete with ninety-eight per cent alpha cellulose in the form of wood pulp at prices much above ten cents per pound. Hog lard cannot compete with hydrogenated oils except at a price concession. Sucrose from cane and beets probably will not long withstand the competition of levulose from Jerusalem artichokes and dextrose from corn. Lumber and other traditional building materials are already giving way in part to newer synthetic or fabricated materials.

According to Dr. Hale, low prices for basic commodities must be the normal rule of the future, rather than the symptom of depression. The chemist will see to it that this is so. This does not mean the death of agriculture and forestry, but it does mean that these pursuits must become industries in the modern sense of the word and that those engaged in them must regard themselves primarily as producers of chemical raw materials. New crops, new methods, and new markets must be the order of the day.

These ideas may cast the chemist in the rôle of villain or of agent of progress, according to one's prejudices, but they are worthy of serious consideration in any case.

Near East College Association

ROBERT COLLEGE WITH FORTRESS OF MOHAMMED II (1452)
This photograph was taken from the Asiatic side of the Bosphorus.

AMERICAN INFLUENCES ON CHEMICAL RESEARCH AND EDUCATION IN THE NEAR EAST

CHARLES A. AND LOUISE MCD. BROWNE, U. S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

In the winter and spring of 1930 the writers made a rather extensive tour by steamship and automobile through the oriental countries bordering upon the Mediterranean Sea. Egypt, Palestine, Syria, Turkey, and Greece were visited in the order named and in each of these countries they were greatly impressed by the extent and growing importance of American influences upon chemical research and education. Fully equal to the pleasure of becoming acquainted with fellow countrymen and women in the various educational institutions of the Mediterranean countries was the satisfaction of meeting native teachers who had received a part of their training in the experiment stations and universities of the United States. Associations of this character establish bonds of appreciation and fellowship which greatly enhance the pleasures of travel and the writers on more than one occasion had the experience in the Near East regions of feeling more at home than in many of the countries of Europe.

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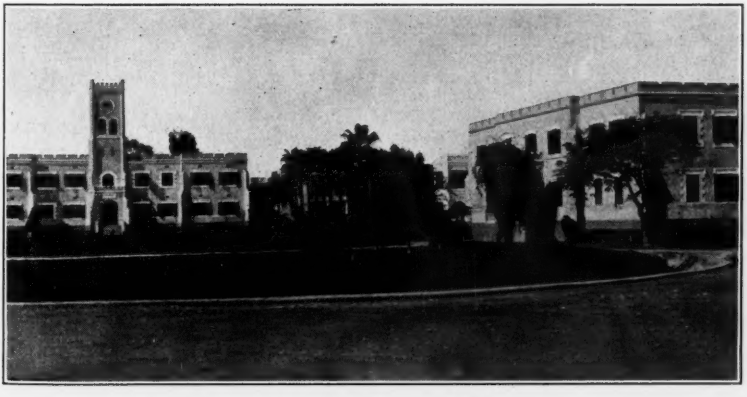
Egypt

ASYUT COLLEGE

In a voyage up the Nile in company with several fellow Americans, among whom were Prof. H. N. Russell of Princeton University and family



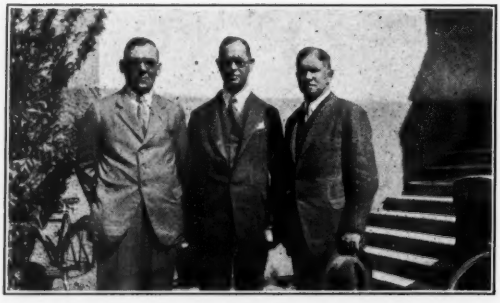
ASYUT COLLEGE, ASYUT, EGYPT
Alexander Hall at the left; Science Hall at the right.

and Dr. Charles A. Richmond (formerly president of Union College) and Mrs. Richmond, a visit was paid to Asyut College of the American Mission which has upon its faculty fifteen American and thirty native teachers.

This photograph was taken from the Asiatic side of the Bosphorus.

This college, which started in a stable in 1865, has now grown to a splendidly equipped institution with fine buildings and a beautiful campus near the Nile and adjoining the great Ibrahimia Irrigation Canal. President Charles P. Russell (Ph.D., Chicago, 1923) escorted our party through the grounds and buildings of the college. Instruction is given to about 750 students in English, Arabic, French, mathematics, geography, agriculture, chemistry, biology, history, religion, and various other subjects. The chemistry courses are given in Science Hall under the general direction of Professor William W. Hickman (Ph.D., Chicago, 1909), who explained to us the work of instruction in this science, in which he is assisted by Samuel P. Miller, instructor (B.S., Wooster College). The following information concerning the chemistry courses is quoted from the catalog of Asyut College for 1927–28.

Two chemical laboratories afford individual places for 400 students. Each laboratory will accommodate 40 students at one time. Every student is provided with individual equipment including attachments for water and gas, and a set of the most common chemicals. Cases of chemicals and hoods are conveniently situated for student use. The laboratories are well lighted and ventilated.



DR. CHARLES P. RUSSELL, President of Asyut College (*center*); DR. WILLIAM W. HICKMAN, Professor of Chemistry (*left*); DR. FOREST S. THOMPSON, Professor of Religious Education (*right*)

One well-arranged lecture room accommodates 50 students. It is equipped with chairs with side-arms and raised seating. The lecture table is fitted with water, gas, electricity, and complete apparatus for lecture demonstrations.

A special balance room affords students a place where they may work without distraction.

A dark room, store rooms, and a preparation room for the use of teachers are also found in this department.

Instruction in chemistry is given in the literary, arts, and science courses.

The students of the Special Science Course have eight periods per week in inorganic chemistry in their fourth year. In this course chemistry is taught in the English language. The text is, "Essentials of Chemistry," by HESSLER and SMITH. Special care is given to the experimental work by the students.

In the fifth year of the Special Science Course, Qualitative Analysis is studied throughout the year, five periods per week. After learning

CLASS IN QUALITATIVE ANALYSIS, CHEMICAL LABORATORY, ASYUT COLLEGE, ASYUT, EGYPT

the methods of procedure of separation and identification of the ions, each student is required to analyze twenty unknown, simple salts, and later to analyze three or four mixtures containing several compounds each. Following this he is given experimental work on alloys and insoluble salts.

Organic Chemistry is also taught to the fifth year of the Special Science Course, five hours per week. Students are required to prepare the more common organic compounds in the laboratory. This is supplemented by the teacher who, in addition to the lectures, performs some of the more difficult preparations. The text is MOORE'S "Outlines of Organic Chemistry." NORRIS' "Laboratory Manual" is used.

The Arts Course provides Elementary Chemistry, six hours per week for one year. The students perform some of the more common experiments in the laboratory.

Students of the Literary Course are given three periods per week of inorganic chemistry. This is taken in the last three years of the course. Laboratory work is required.

Students of the Scientific Course have eight hours per week in inorganic chemistry. They begin this study in their second year and continue the study through four years. The ordinary laboratory experiments are performed by the students.

The graduates of Asyut College occupy responsible positions as teachers, physicians, merchants, planters, pharmacists, lawyers, engineers, clergymen, and Government employees, and are playing an important part in the cultural, economic, and industrial development of modern Egypt.

NEW FRUIT PRODUCTS LABORATORY, GIZA AGRICULTURAL EXPERIMENT STATION, CAIRO, EGYPT

GIZA AGRICULTURAL EXPERIMENT STATION

Very close to the ancient Pyramids of Egypt are the extensive grounds and modern buildings of the Giza Agricultural Experiment Station. The young native experts in charge of the various departments of this institution have received the best training which the universities of Europe and the United States can supply. Several of them had studied at the University of California and at the time of our visit were busily engaged in applying the results of their American agricultural training to Egyptian conditions. Investigations are conducted at the Giza Experiment Sta-

PREPARING CHEMICALS FOR ORCHARD FUMIGATION, GIZA AGRICULTURAL EXPERIMENT STATION, CAIRO, EGYPT

FUMIGATING ORANGE TREES, GIZA AGRICULTURAL EXPERIMENT STATION, CAIRO, EGYPT

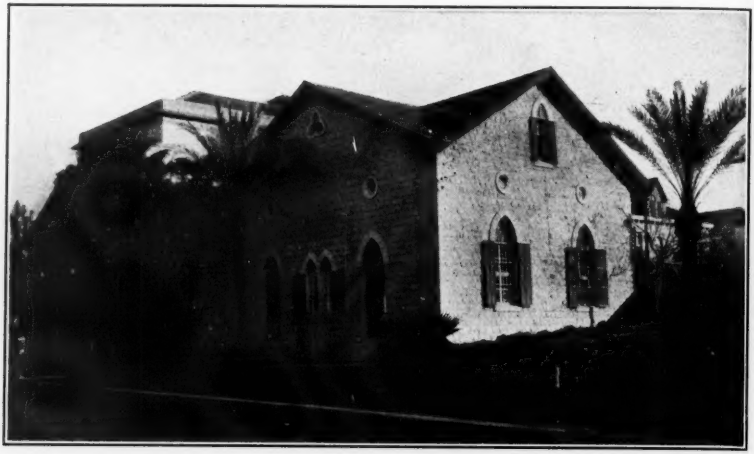
Dr. Abbas H. El-Sawy (Ph.D., University of California) standing in the foreground.

tion upon sugar cane, cotton, fruits, cereals, vegetables, fodder plants, soils, irrigation, insect control, animal industry, plant and animal diseases, silk production, agricultural technology, and the various other branches of agriculture. Various phases of this research work were explained under the guidance of Dr. Abbas H. El-Sawy, a graduate of the University of California. In the new Fruit Products Laboratory of this station investigations are performed upon the chemical composition of the fruits grown in Egypt and upon methods for their utilization in the manufacture of jams, preserves, beverages, and other products. The control of noxious insects by fumigation and other means is another subject which is demanding the attention of the agricultural chemists of the Giza station. The methods employed in California upon citrus trees are now being applied to the fruit orchards of Egypt.

Syria

AMERICAN UNIVERSITY OF BEIRUT

In Syria we paid two very interesting visits to the American University of Beirut where the courses in chemistry are comparable with those of the higher institutions of the United States. The chemistry courses in the School of Arts and Sciences are conducted by Professor Harold W. Close, Ph.D., Associate Professor William A. West, B.A., Adjunct Professor Nicholas Constan, Pharm.M., Instructor Ralph B. Patch, B.A., Instructor Farajallah Azrak, B.A., and Teaching Fellow 'Arafât Duwayk,



OLD CHEMICAL LABORATORY, AMERICAN UNIVERSITY OF BEIRUT, SYRIA

B.A. The following information concerning the chemistry courses is quoted from the catalog of the American University of Beirut for 1928–29.

A laboratory deposit of $2.50 is required for each semester course in chemistry.

Note.—Courses 101, 102, 201, 202 are required for entrance to the schools of medicine and dentistry. Courses 101, 102 are required for entrance to the school of pharmacy, and of engineering students.

101, 102. GENERAL CHEMISTRY.—This is a course in the fundamental principles of chemistry and their application in modern everyday life. It is designed not only to meet the requirements of the professional schools but also to give the student a broader outlook on life, and to reveal to him some of the wonders of modern science. The course includes a study of the fundamental laws and theories of chemistry, as well as the methods of preparation, the properties, reactions, and uses of the principal elements and their most important compounds. Special emphasis is placed on the practical work done by the students in the laboratory. DEMING, "General Chemistry." CLOSE AND AZRAK, "Laboratory Manual of General Chemistry." 4 hr. lectures and recitations, 2 hr. laboratory, 2 terms. Laboratory fee, $4.00.

201. PHYSICAL AND ANALYTICAL CHEMISTRY.—This is a course in elementary physical chemistry, and includes a study of the gas laws, chemical equilibrium and the law of mass action, osmotic tension and the modern theory of solutions, enzyme action and catalysis, hydrogen-ion concentration, colloids, etc. In the laboratory the major part of the time is spent in systematic qualitative analysis which offers abundant illustrations of the practical application of the laws and theories studied in connection with the lectures and recitations. This is followed by a

limited amount of volumetric analysis. The course is especially designed to meet the needs of students planning to enter the professional schools or to specialize in chemistry, and is prerequisite to all later courses in chemistry. FINDLAY, "Physical Chemistry for Students of Medicine." CLOSE AND AZRAK, "Laboratory Manual of Elementary Qualitative Analysis." Prerequisites: Chemistry 101, 102. 3 hr. lectures and recitations, 3 hr. laboratory, 1st term. Laboratory fee, $3.75.

202. ORGANIC CHEMISTRY.—This is an elementary course intended to give the student a general knowledge of the various types of organic compounds. The structure, general methods of preparation, and general reactions of the hydrocarbons, alcohols, aldehydes, ketones, acids, esters, ethers, carbohydrates, and nitrogen derivatives are taken up, followed by a more detailed study of a few common examples under each class, chosen from both the aliphatic and the aromatic series. MOORE, "Outlines of Organic Chemistry." Prerequisite: Chemistry 101, 102 or its equivalent. 3 hr. lectures and recitations, 3 hr. laboratory, 2nd term. Laboratory fee, $3.75.

301. QUANTITATIVE ANALYSIS, PART I.—This is a practical course intended to acquaint the student with the methods and technic of chemical analysis. The emphasis is placed upon neatness and accuracy of the work done, rather than upon the number of determinations made. The manipulation of the analytical balance is first taught, followed by representative gravimetric analyses, giving practice in the different methods of procedure. The preparation and standardization of volumetric solutions is then taken up, and determinations are made by acidimetric, alkalimetric, iodometric, and oxidimetric methods. CUMMING AND KAY, "Quantitative Chemical Analysis." Prerequisites: Chemistry 101, 102; 201. Lectures and recitations, 1 hr.; laboratory, 5 hr., 1 term. (The course may be taken either the first or the second term.) Laboratory fee, $5.00.

302. QUANTITATIVE ANALYSIS, PART II.—This course is a continuation of Chemistry 301. Systematic analysis of ores, dolomite rocks, alloys, and allied substances is undertaken, using both gravimetric, and volumetric methods. Prerequisites: Chemistry 101, 102; 201, 301. 6 hr. laboratory, 1 term. (This course may be taken either the first or second term.) Laboratory fee, $5.00.

303. QUANTITATIVE ANALYSIS, PART III.—This course is a continuation of Chemistry 301 and 302. Water analysis, oil and fat analysis, and the analysis of food and industrial products is undertaken illustrating gasometric, refractometric, colorimetric, and other methods of analysis not met with in the previous courses. Prerequisites: Chemistry 101, 102; 201; 301, 302. 6 hr. laboratory, 1 term. (This course may be taken either the first or second term.) Laboratory fee, $5.00.

305, 306. MODERN CHEMICAL THEORY.—This is a course in physical chemistry designed for students who have chosen chemistry as a major and is especially adapted to the needs of those who intend either to teach science or to employ chemistry in industrial enterprises. The fundamental principles which form the framework of the science are studied in a much more exhaustive way than is possible in the more elementary courses. This course is required of all students majoring in chemistry. Given every other year, alternating with chemistry 307, 308. GETMAN,

"Outlines of Theoretical Chemistry." Prerequisites: Chemistry 101, 102; 201, 202; Physics 201, 202. 3 hr. lectures and recitations, 3 hr. laboratory per week for two terms. Laboratory fee, $3.75. (Not given in 1929–30.)

307. INDUSTRIAL CHEMISTRY.—This course includes a study of the more important manufacturing processes in which chemistry plays a leading part, especially those in operation or capable of development in this part of the world. The object of the course is to point out ways in which a knowledge of chemistry may prove of practical value in developing and improving local industries by the application of modern scientific methods. The course consists of lectures, supplemented by assigned reading, together with a weekly period of laboratory work. Prerequisites: Chemistry 101, 102; 201, 202. 3 hr. lectures or recitations, 3 hr. laboratory, 1st term. Laboratory fee, $3.75.

308. AGRICULTURAL CHEMISTRY.—This course is analogous to chemistry 307, and its aim is to acquaint the student with the ways in which a knowledge of chemistry may prove of practical value in developing and improving agriculture by the application of modern scientific principles. Especial emphasis is placed on the chemistry of soils and fertilizers, the analysis of which forms the laboratory work of the course. Prerequisites: Chemistry 101, 102; 201, 202. 3 hr. lectures or recitations and 3 hr. laboratory, 2nd term. Laboratory fee, $3.75.*

In the School of Medicine of the American University of Beirut instruction is given in biological chemistry by Associate Professor Stanley E. Kerr, Ph.D., Instructor Vartan H. Krikorian, Pharm.M., and Assistant Muḥyiddîn Maḥmaṣâni, Phar.G. The following information is quoted from the university catalog for 1928–29.

BIOLOGICAL CHEMISTRY.

First Year. This course includes the chemistry of the constituents of the animal body, particularly carbohydrates, fats, and proteins; the chemical changes which occur during the processes of digestion and metabolism; the chemistry of blood and urine; the mechanisms which regulate neutrality in the body; hormones; and nutrition. The laboratory work supplements the lectures. The student studies the composition of the body tissues, the chemistry of their constituents, and the processes of digestion. Considerable time is given to the quantitative analysis of both urine and blood, and the students observe the effect of diet by experiments on themselves and on laboratory animals. BODANSKY, "Introduction to Physiological Chemistry," and KERR, "Laboratory Manual of Biological Chemistry." Lectures and recitations 4 hr., laboratory 9 hr., 1st term. Laboratory fee, $12.50. Deposit: $2.50.

* It is worth mentioning that American influences upon chemical education in Syria date back over 50 years. In 1869 the American Mission Press of the Syrian Protestant College (now the American University) of Beirut published the "Larger Chemistry" of C. V. A. Van Dyck in Arabic text for the use of Syrian students. An "Elementary Chemistry" by the same author was also published in Arabic in 1886 under similar auspices. The same press also published in Arabic the "Chemical Analysis" (1876) and the "Chemistry of the Air and Water" (1879) of E. R. Lewis.

NEW CHEMICAL LABORATORY, AMERICAN UNIVERSITY OF BEIRUT, SYRIA

The photograph shows the laboratory in course of construction. The laboratory was ready for occupancy October, 1930.

Seminar. During the second term of the first year a seminar is conducted in which recent advances in biological chemistry are discussed. This course is open to a limited number of students who have completed the regular course in biological chemistry. Credit is given only to students doing graduate work. 1 hr., 2nd term.

The laboratory facilities of the department are, by special arrangement with the head of the department, available for qualified students wishing to do graduate work.

In the school of pharmacy of the American University of Beirut, in addition to the courses in physical and analytical chemistry, organic chemistry, quantitative analysis, and biological chemistry previously mentioned, the following course is given in pharmaceutical chemistry.

PHARMACEUTICAL CHEMISTRY.—The course is begun with a short review of qualitative analysis where preliminary wet and dry methods of identification are emphasized. The basic ferric acetate method for the separation of phosphate in unknowns is taken up, followed by qualitative reactions for organic substances. The technic of quantitative analysis is applied in the assay of official chemical and pharmaceutical preparations of the U. S. P., B. P., and French Codex. The chemical analysis of water, butter, oils, fats, and waxes; estimation of alcohol in alcoholic preparations; alkaloidal estimation and vegetable drug assays; and the general pharmacopœial tests are included in the course. REMINGTON, "Practice of Pharmacy;" SCHIMPF, "Qualitative Analysis;" SCHIMPF, "Volumetric Analysis" are used as texts. The various pharmacopœias and many reference books are supplied as laboratory equipment. Lecture and recitation, 1 hr.; laboratory, 5 hr., 2 terms. Laboratory fee, $7.50. Deposit, $2.50.

Photographs are shown of the old chemistry building of the American University of Beirut and also of the new chemistry building erected by a grant from the Rockefeller Foundation. The latter structure, in course of erection at the time of our visit, has since been completed. The courses in biological chemistry are given in the new Medical Science Laboratories Building, another Rockefeller Foundation grant, also in course of construction at the time of our visit and now completed. The location of these various chemical laboratories, on an elevation above the blue waters of the Mediterranean and with a glorious outlook upon the snowy peaks of Mt. Lebanon, is superb. Our visit here was made especially pleasant by the courtesies of Professors Stanley E. Kerr (Ph.D. of the University of Pennsylvania), Nicholas Constan (a post-graduate student of the Massachusetts Institute of Technology), and Ralph B. Patch (B.S. of Amherst).

Mr. George B. Stewart, the treasurer and secretary of the American University of Beirut, emphasized the practical policy of this institution in adapting its courses of instruction and research to the practical needs of the Syrian and other Arabic-speaking countries of the Near East. In accordance with this plan the research work of the advanced chemistry

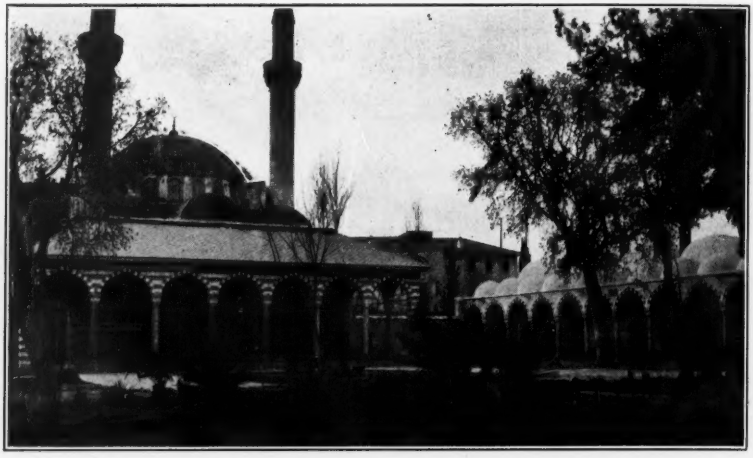
NEW MEDICAL SCIENCE LABORATORIES, UNIVERSITY OF BEIRUT, SYRIA
The photograph shows the laboratory in course of construction. The laboratory was ready for occupancy October, 1930.

courses of the University is devoted in part to such practical problems as the utilization of domestic fruits for the manufacture of preserves, jams, jellies, marmalades, and similar products, and the utilization of olive oil for the manufacture of soap. Among the research problems in biochemistry, Professor Kerr was conducting an investigation upon the composition of the blood corpuscles of the domestic animals of Syria. In connection with this research he has obtained some very interesting results upon the relation of the mineral constituents in the blood corpuscles of the fat-tail sheep.

It is doubtful if any university in the world has a more cosmopolitan group of students than the American University of Beirut, there being no less than thirty different nationalities represented in the registration for 1929–30. Of the total registration of 1458, there were 1289 students from countries in Asia and Africa of whom 579 were Syrians, 250 Palestinians, 152 Armenians, 135 Irakians, 64 Egyptians, and 61 Persians. There were 124 students from 13 different European countries, the Greeks leading with 41, the British following with 30, and the Russians being third with 21. Forty-five students came from the western hemisphere, 35 being from the United States, 6 from Brazil, 2 from Canada, and one each from Ecuador and Mexico.

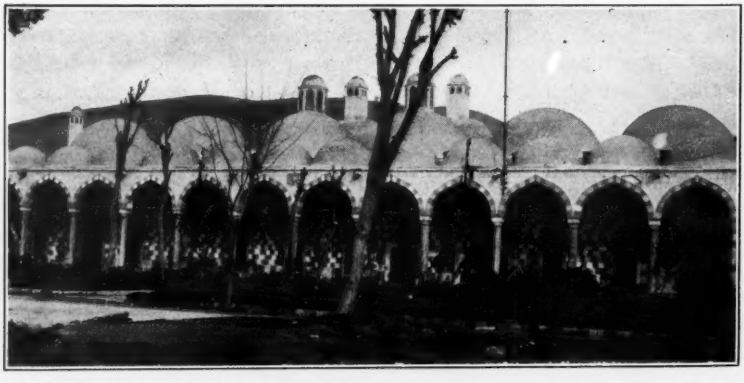
The faculty and staff of the University number 231, with a representation of 14 different nationalities among whom are 91 Syrians, 56 Americans, 30 Armenians, 12 British, 8 French, 8 Russians, and 4 Canadians.

Following the turmoil of political readjustments which have taken place in the Near East since the World War, there has been a great educational



SULTAN SELIM MOSQUE, DAMASCUS, SYRIA

awakening among the native population of these regions. Schools are overcrowded and the scientific ideas of the West are causing a vast reaction as they permeate among the inhabitants of the Mohammedan countries. Many evidences of this transformation were brought to our attention but none of them was of so unique or startling a character as the establishment of modern scientific laboratories in the arcades of the old Sultan Selim Mosque in the ancient Moslem city of Damascus. Here in rooms which in the old bygone days were once occupied by Mohammedan de-



CHEMICAL AND PHYSICAL LABORATORIES IN THE ARCADES OF THE SULTAN SELIM MOSQUE, DAMASCUS, SYRIA

The mast attached to the front of the Arcades supports the antenna of a radio receiving apparatus.

votees during their pilgrimages to this sanctuary, are installed chemical and physical laboratories well equipped with balances, polariscope, spectroscope, radio outfit, and other apparatus suitable for purposes of general instruction. The scene of eager-faced native boys, thirsty for a knowledge of chemistry and physics, in the quadrangle of this beautiful old mosque, one of the sacred places of Islam, affords the western visitor a rare opportunity for philosophic reflection.

In the great educational and economic reconstruction of the Near Eastern countries, which is now under way, the American University of Beirut is taking an important and leading part.

AMERICAN JUNIOR COLLEGE FOR WOMEN OF BEIRUT

In Beirut also is The American Junior College for Women which is conducted under the auspices of the Syria Mission of the Board of Foreign Missions of the Presbyterian Church of the U. S. A. This institution is located near the American University which makes it possible for its students to use the University libraries and laboratories. The following chemical courses are listed in the catalog for 1928–29.

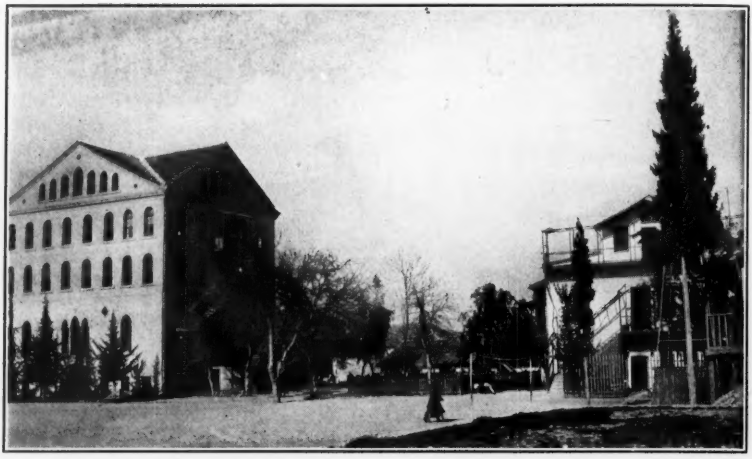
Freshman. GENERAL INORGANIC CHEMISTRY. The course includes a study of the fundamental laws and theories of chemistry, combined with a study of the principal elements and their most important compounds. Attention is drawn to many of the practical applications of modern chemistry. DEMING: "General Chemistry." 4 lectures and recitations, 2 hr. laboratory, 2 terms.

Sophomore. PHYSICAL AND ANALYTICAL CHEMISTRY. This course is designed to meet the needs of students preparing for medical school or specializing in chemistry. The lectures and recitations make up a course in elementary physical chemistry. The laboratory work covers a course in qualitative analysis, stressing phases of physical chemistry, and closing with a brief survey of volumetric analysis. FINDLAY: "Physical Chemistry for Students of Medicine." BAILEY AND CADY: "Qualitative Analysis," to be supplemented by additional mimeographed instructions. Prerequisite: Freshman Chemistry. 3 hr. lectures and recitations, 3 hr. laboratory, 2nd term.

Turkey

AMERICAN SCHOOL OF TARSUS

Continuing our journey in the Near Eastern countries to Turkey we visited the American School at Tarsus (the ancient home of St. Paul), the International College at Smyrna, and Robert College and the Constantinople Woman's College in Constantinople. The American colleges in Turkey have all passed through a most serious crisis as a result of the reorganization and exchange of populations which took place under the new conditions that arose in Turkey in 1923. The several colleges established under the auspices of the American Board of Foreign Missions were con-



AMERICAN SCHOOL AT TARSUS, TURKEY

fronted with the alternative of either migrating, as was done by Anatolia College in Marsovan, or else of relinquishing the religious features of the work for which they were originally established and devoting themselves solely to secular education. As a result of the exchange of populations the American schools at Tarsus and Smyrna lost, in large part, their Christian students of Greek and Armenian parentage, with the result that the student bodies of these institutions are now composed almost exclusively of Mohammedans. Of the 70 students in the American School of Tarsus, 65 are Moslems and of the 303 students at the International College of Smyrna only 8 are Christians. We were conducted through the buildings of the school at Tarsus by Mr. Hazen (Yale, '27). There was a small laboratory here where elementary instruction is given in chemistry. The studies are of a practical nature, the young Turkish boys being taught among other subjects carpentry and mechanical shop work.

INTERNATIONAL COLLEGE OF SMYRNA

President Cass Arthur Reed escorted us through the buildings and grounds of the International College of Smyrna. Elementary instruction is given here in chemistry. A course in agriculture and a college farm have been established under the general direction of Mr. White, a graduate of the Kansas Agricultural College. The college farm is situated upon the banks of the Meles, a classic stream, near the ruins of an old Roman aqueduct. A lathe and shop machinery have also been installed to provide students with practical instruction in these subjects.

The American schools at Tarsus and Smyrna are performing a most valu-

MAIN BUILDING, INTERNATIONAL COLLEGE, SMYRNA, TURKEY

able educational work in serving the practical economic and social needs which are necessary for the upbuilding of the new Turkey. The institutions are growing and there is a great need of enlarged facilities for classrooms and laboratories.

ROBERT COLLEGE OF CONSTANTINOPLE

The movement of exchanging populations has affected the American colleges in Constantinople less than in other parts of Turkey. The student body of Robert College, the best known institution for higher education in Turkey, according to the catalog of 1929–30, consists of 391 Moslems, 171 Greek Orthodox, 79 Armenian Gregorians, 35 Protestants, 29 Hebrews, and 12 Roman Catholics. These 717 students are distributed among 20 different nationalities of whom 540 are Turks, 71 Bulgarians, 29 Greeks, 13 Persians, 10 Albanians, and 9 Americans. The teaching staff of the college in 1929–30, numbered 98, of whom 34 were Americans, 22 Turks, 8 Armenians, 7 Greeks, and 5 British.

The industrial and engineering courses of Robert College are the finest of any institution in the Near East. The shops are splendidly equipped with all the mechanical, electrical, hydraulic, and other appliances necessary for advanced work in any of the fields of engineering. The future prosperity of the Near East depends upon the industrial development of its natural resources and Robert College is serving a most useful purpose in supplying each year scores of well-trained engineers who are taking a leading part in the upbuilding of the various countries which border upon the Eastern Mediterranean.

The chemistry department of Robert College at the time of our visit (March, 1930) was under the direction of Professor Jervis Moissan Fulmer (Ph.D., University of Colorado, 1925) who very kindly conducted us through the college buildings and grounds. The chemistry courses, according to the catalog for 1929–30, are classified as follows:

1–2. GENERAL CHEMISTRY. Study of elements and their compounds; elementary study of the theories governing chemical reactions. Laboratory work includes experiments in qualitative analysis. Text: MCPHERSON AND HENDERSON, "Chemistry and Laboratory Manual." Required in A.B. course and B.S. courses in agriculture and commerce. 2 hr., lecture; 1 hr., laboratory. Sophomore year.

3–4. GENERAL CHEMISTRY. The fundamental principles of chemistry. Study of the metallic and non-metallic elements and their compounds. Text: HOLMES, "Introductory College Chemistry;" SNEED AND KIRK, "Laboratory Manual." Required in B.S. courses in biology and natural sciences. 3 hr., lecture; 1 half-day, laboratory in B.S. course in biology. 2 hr., lecture; 1 half-day, laboratory in B.S. course in natural sciences. Sophomore year.

5. QUALITATIVE ANALYSIS. Study of the fundamental principles of qualitative analysis and laboratory work on the analysis of metallic and non-metallic ions, compounds, and alloys. Text: CLOSE AND AZRAK, "Qualitative Analysis." Required in B.S. course in natural sciences. 2 hr., lecture; 2 half-days, laboratory. Junior year. Prerequisite: Chem. 1–2 or 3–4.

6. QUANTITATIVE ANALYSIS. Preliminary gravimetric and volumetric analyses; gas, water, and fuel analyses. Text: MAHIN, "Quantitative Analysis." Elective. 2 hr., lecture; 2 half-days, laboratory. Prerequisite: Chem. 5.

*7–8. ORGANIC CHEMISTRY. Study of organic chemistry with emphasis on practical applications. Laboratory preparations in the aliphatic and aromatic series. Text: NORRIS, "Organic Chemistry." Elective. 2 hr., lecture; 1 half-day, laboratory. Prerequisite: Chem. 1–2 or 3–4.

Robert College is most pleasantly situated upon a headland overlooking the Bosphorus and the historic walls of old Turkish fortifications. From its beginning in 1863 the college has been independent of any mission board, being governed by its own trustees. Robert College and the American University of Beirut were incorporated at the same time under the same act, both institutions holding their charters under the board of regents of the State of New York.

Greece

Greece, which from early historic times has always been the intermediary between Eastern and Western cultures, has presented to American teachers another type of problem, resulting from the after-effects of the World War, which is very different from those previously noted. This is the problem

* Given in alternate years beginning with 1929–30.

VIEW OF BOSPHORUS AND OLD TURKISH FORTIFICATIONS FROM ROBERT COLLEGE, CONSTANTINOPLE, TURKEY

of helping the people of Greece to educate and assimilate over 1,000,000 compatriots who were conveyed to their towns and cities as refugees during the exchange of populations which followed the disaster of Smyrna in September, 1922. The labor of providing food, shelter, and occupations for this vast addition to its population has been one of the greatest burdens which any country has been required to assume. Many Americans have dedicated not only their best energies but their very lives to this work of restoration in afflicted Greece. The distinguished American agricultural chemist, the late Prof. Cyril G. Hopkins of Urbana, Illinois, who in 1918 and 1919 made a most extensive survey of the soils of Greece, was a martyr to this cause. His name will long be mentioned in Greece with grateful affection and remembrance.

Courtesy of Dean H. W. Mulford, University of Illinois College of Agriculture

CYRIL GEORGE HOPKINS

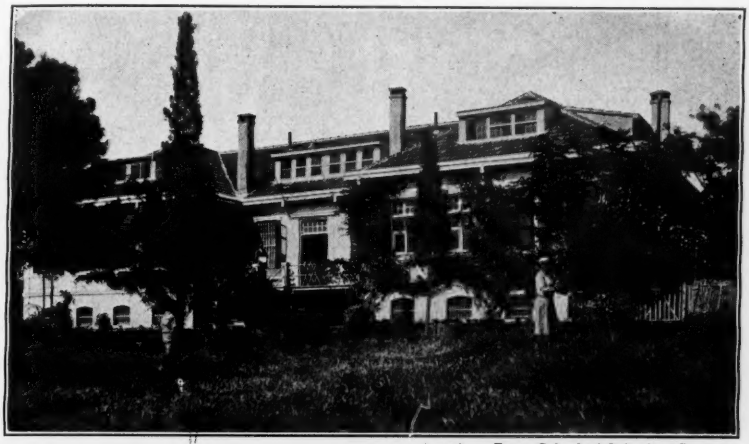
July 22, 1866–October 6, 1919
Professor of Soil Fertility, University of Illinois.

ANATOLIA COLLEGE

While our boat was anchored in the harbor of Salonica a visit was paid to Anatolia College which was first established as an American mission school in Marsovan, Turkey, in 1881. During the exchange of populations, following the Græco-Turkish Convention of January, 1923, a large proportion of the former constituency of Anatolia College migrated to Greece. In 1924 the College, in response to cordial invitations from the Greek government, abandoned its extensive buildings and grounds in Marsovan and reopened its doors in Salonica. It began work in its new field as a refugee institution on a temporary basis but the demand for the type of education which it was prepared to offer was so cordially manifested that its board of trustees soon decided to reëstablish the college in Greece upon a permanent basis.

President George E. White (D.D., Grinnell College) explained the purpose of Anatolia College which is to give its students a liberal education rather than a specialized training. A temporary annex has been built to house the chemistry, physics, and biological laboratories until funds are available for the erection of a permanent structure.

Elementary chemistry is taught at Anatolia College as an elective course, in the sixth form or sophomore class, of three periods of recitation



American Farm School of Salonica, Greece

JAMES HALL OF THE THESSALONICA AGRICULTURAL AND INDUSTRIAL INSTITUTE, KNOWN ALSO AS THE AMERICAN FARM SCHOOL OF SALONICA, GREECE

and three periods of laboratory work per week. Instruction is given in a general study of the common elements and compounds; the gas laws; periodic table; simple reactions; and writing of equations. The aim is to give students a good general idea of the chemical nature of things around them.

THESSALONICA AGRICULTURAL AND INDUSTRIAL INSTITUTE

While we were in Salonica a visit was also paid to the American Farm School, also known as the Thessalonica Agricultural and Industrial Institute, which is only about two miles from Anatolia College. The farm of this school with its buildings, orchards, gardens, and fields, is beautifully located on a gentle slope, about 250 feet above the sea, with a magnificent view of Mt. Olympus. The Thessalonica Agricultural and Industrial Institute was founded by Rev. John Henry House and incorporated in 1904 under the laws of the State of New York. After a very cordial welcome by Dr. House (who, a veteran in the missionary field, is still active at the age of eighty-six) he explained the purposes and work of his school. The Institute is international in its aim, boys of Greece and of other neighboring countries being received for instruction in those branches of agriculture which are of most importance to the upbuilding and improvement of the impoverished regions of the Balkan states. The operation of tractors, erection of buildings, digging of wells, construction of roads, drainage of land, cultivation of fields, pruning and grafting of orchards, and care of farm animals are examples of the very practical training which boys receive at the American Farm School of Salonica. It was a great pleasure,

Near East College Association

BENAKI HALL, ATHENS COLLEGE

under the guidance of Dr. House, to inspect the dormitories, classrooms, laboratories, barns, and fields of this most serviceable institution. There is also here a very interesting museum with exhibits of the primitive farm implements, bee hives, soils, crops, wool, silk, and other agricultural products of the Balkan regions.

The instruction in chemistry at the Thessalonica Agricultural and Industrial Institute is of a very general character, particular stress being laid upon the application of chemistry to the needs of agriculture and of daily life.

About 120 pupils are enrolled at this school, most of whom are Greek boys coming from nearly every section of Macedonia, Thrace, Epirus, and the various Islands. The great value of the Institute in helping to improve the agricultural and industrial conditions of the people has been recognized by the Greek Government and Premier Venezelos, after a personal visit, created through appropriate legislation one hundred scholarships for which Greek boys of exceptional promise are being picked in the different parts of the country.

"Learning by Doing" is the very concise practical motto of the Thessalonica Agricultural and Industrial Institute whose graduates are playing an increasingly important part in the upbuilding of the Balkan sections of the Near East.

ATHENS COLLEGE

In Athens we were enabled to pay a very interesting visit to Athens College under the guidance of President Henry B. Dewing. This institution, which has been made possible by the combined support of Greek and American endowments, offers instruction in preparatory courses to Greek

boys between the ages of ten and eighteen years, which corresponds also to the general age of the pupils at Anatolia College and the American Farm School in Salonica. The present curriculum of Athens College is that of a high school where students are prepared for the broader discipline of the four years of college training. The buildings of the institution, Benaki Hall and Kehaya Hall, constitute only a part of the future equipment of the college which is beautifully located in the pleasant suburbs of Athens on the road to Kephesia with a fine outlook toward the classic mountains of Pentelicus and Hymettus.

Mr. Elevtheroudakis of Athens has recently made a generous gift of laboratory equipment which with further additions will soon be installed in the new χημειον or laboratory building devoted to chemistry and physics. Athens College, now in its sixth year, has a registration (1929–30) of 310 students. It is a growing institution and is destined to play a leading part in the training of Greek boys for their future work as citizens of the republic.

AGRICULTURAL CHEMICAL RESEARCH IN GREECE

During our stay in Athens a visit was paid to Minister of Agriculture Spirides who very kindly delegated Dr. Socrates A. Kalogereas (Ph.D., University of California), Technologist of the Ministry of Agriculture, to explain the chemical research work which is being conducted in Greece upon olives, olive oil, currants, grapes, raisins, and other agricultural products of the country. Dr. Kalogereas is now applying and extending in Greece the results of the agricultural-technological experience which he acquired under Prof. W. V. Cruess at the University of California. It is remarkable how many of Dr. Cruess' former students are scattered through the Near Eastern countries. We met them in Egypt, Syria, and Greece and they are all performing work of the greatest value in developing the agricultural resources of their respective countries.

Under the guidance of Dr. Kalogereas a visit was paid to the Agricultural High School of Athens, an institution located upon the Sacred Way adjacent to an ancient olive tree, which according to tradition was once a part of the groves of Academe, where Plato had his school of philosophy. In the buildings of this high school, which have a fine prospect of the Acropolis, the Parthenon, and other ruins of ancient Athens, are laboratories for research work in chemistry, agricultural technology, horticulture, animal husbandry, and other branches of agriculture. Courtesies were extended here by Prof. Papandreos, director of the high school and by various members of the faculty. Among the latter is Dr. Panos Anagnostopoulos, professor of horticulture, a graduate of the University of Wisconsin, who explained the work which he is conducting upon the fruits of Greece and the methods for their utilization.

CORDIALITY OF AMERICAN AND GREEK RELATIONS

Our visit to Greece marked the termination of our tour through the Near East countries. In Greece as elsewhere the visitor is impressed with the cordial attitude toward Americans and the friendly spirit of coöperation not only in education but in the fields of culture and social welfare. One of the finest examples of these harmonious relations was the donation by the Greek scholar and bibliophile, Dr. Joannes Gennadios (formerly Greek Minister to England), of his extensive library of 30,000 books upon Greek history, culture, science, and art to the American School of Classical Studies in Athens. The collection is housed in a beautiful temple, called the Gennadeion, at the foot of Mount Lycabettus near the American School. Many pleasant hours were spent in examining the books of this library which is under the direction of Dr. G. C. Scoggin. The vestibule of the building, which was erected by the Carnegie Corporation, bears a tablet with the following inscription, indicative of the spirit which actuated the donor of the library when he made his bequest:

"Given to the American School of Classical Studies to hold aloft the light of truth and freedom and to guard the friendship of Hellas and Hesperia forever."

Every Third Person "Tasteblind" to *p*-Ethoxyphenylthiourea, an Intensely Bitter Chemical. "Tasteblindness" is the only term that can be found to describe the reaction of a fortunate forty per cent of folk who cannot taste *p*-ethoxyphenylthiourea. For the other sixty per cent find it intensely bitter—bitter as gall, bitter as quinine, bitter enough to make them go round sticking out their tongues and making wry faces for an hour.

This curious difference in perception has been discovered by Dr. Arthur L. Fox, of the laboratories of E. I. du Pont de Nemours and Company of Wilmington. He has tried this very complex organic compound on everybody who would volunteer to taste it, and has found that approximately three-fifths of his "victims" declare it intensely bitter, while the rest say that it "has no more taste than sand."

When two persons, one "tasteblind" and the other not, try it at the same time a lively argument is likely to ensue. Dr. Fox tells of a debate he started in his favorite chow mein restaurant by giving two of the waiters a taste. One "got it" and the other didn't; and the things they said to each other in Chinese as they went back toward the kitchen made even the long Greek name of the chemical sound tame. Then they came back for another taste to get the matter really settled—and started the argument all over again.

p-Ethoxyphenylthiourea is an innocent-looking white stuff, usually available in coarsely powdered form. It is a close chemical relative to another compound, known to the trade as "dulcin," which is several hundred times as sweet as sugar. To make dulcin, one atom of sulfur is dislodged from the molecule of *p*-ethoxyphenylthiourea and an atom of oxygen substituted for it.

Dr. Fox has found that this curious "tasteblindness" is displayed by the same persons to other compounds as well, all of them of the thiourea group. But so far as known, dulcin tastes exceedingly sweet to everybody.—*Science Service*

THE ELECTRON IN ORGANIC CHEMISTRY. II. BONDS OF THE ETHYLENE TYPE AND FACTORS INFLUENCING DIRECTED ADDITION THEREAT*

M. S. KHARASCH, UNIVERSITY OF CHICAGO, CHICAGO, ILLINOIS, AND OTTO REINMUTH, ASSOCIATE EDITOR

Some earlier hypotheses concerning the nature of the double bond and some empirical rules regarding the behavior of ethylene derivatives in addition reactions are outlined and their limits of utility are pointed out. Several contemporary concepts are discussed briefly and their outstanding defects are noted. Particular attention is paid to the theory of alternating polarity and its weaknesses.

The fundamental principles set forth in the first article of this series are extended and applied in a presentation of the authors' concept of the nature, formation, and chemical behavior of the double bond. The thermal evidence which suggests the electronic constitution of the double bond postulated by the authors is discussed.

Directed additions of halogen acids to unsymmetrical ethylene derivatives are interpreted in terms of the electronic theory. Studies now in progress on certain very delicately balanced olefine derivatives under precisely controlled experimental conditions indicate that minor supplements and refinements to the basic theory here outlined may be necessary to deal satisfactorily with compounds of this type. These are, however, comparatively rare and it seems reasonably probable that the theory in its present form will remain adequate to deal with the vast majority of ionic addition reactions. At any rate it is offered as furnishing the most satisfactory general picture of the facts at present recorded in the literature. A reasonably complete tabulation of recorded halogen acid addition data is presented.

Ease of addition and relative stabilities of addition products are discussed and explained in terms of electronic configurations.

The evidence for the existence of ethylenic electro-isomers is outlined and the corollary experimental phenomena are noted.

Some criticisms of the authors' views which have appeared in the literature are shown to be based upon misinterpretations of those views.

. . . . . .

Introduction

It would be superfluous to review here the evidence for the existence of the double bond and for the statement that the double bond is not, from the chemical standpoint, the precise equivalent of two single bonds. These ideas are well-substantiated and universally accepted. Nor do we believe it desirable to burden the reader with an exhaustive historical résumé of hypotheses concerning the nature and behavior of the double bond. We shall confine ourselves to a brief preliminary examination of those views

* The first article of this series appeared in J. CHEM. EDUC., 5, 404–18 (Apr., 1928).

which have achieved sufficient prominence to make their way into textbooks and to a statement of their limits of usefulness.

Roughly classified, the views which shall engage our attention fall into three groups: (1) fundamental attempts to account for the behavior of double-bond compounds in general without differentiating between individual compounds nor predicting the courses of specific reactions; (2) empirical rules intended to describe or predict certain phenomena without offering explanations thereof; and (3) systems which seek to combine description or prediction with explanation.

Non-Predictive Hypotheses Concerning the Nature of the Double Bond

Baeyer's Strain Hypothesis. Baeyer's (*1*) "strain" hypothesis belongs to the first class. This ingenious interpretation treats the double-bond compound as a special case of the cyclic compound. It is based upon the postulate that the four valencies of the carbon atom may be considered as directed outward from a common center toward the solid angles of a regular circumscribed tetrahedron. They thus diverge from each other at angles of 109° 28′. It is further assumed that any deviation from the normal angle of divergence results in a condition of "strain" evidenced by decreased stability in the bonds formed. Since the degree of "strain" is proportional to the magnitude of the deviation from the normal angle of divergence, the two-membered ring (or double-bond compound) is the least stable of all the ring structures, for in it the deviation from the normal is greatest.

"Dimethylene," said Baeyer, "is, in fact, the loosest ring, for it can be broken by hydrogen bromide, bromine, and even iodine; trimethylene is loosed only by hydrogen bromide but not by bromine; tetramethylene and hexamethylene are difficult or impossible to break." He added that the validity of his theory of the double bond and of methylene ring structures in general could be tested by a study of the thermal behavior of the various rings.

However, the heats of formation of di- and polymethylene derivatives as calculated by Stohmann and Kleber (*2*) were not in complete accord with the relative degrees of "strain" postulated by Baeyer, and the discrepancy in the case of ethylene (dimethylene) was particularly marked. Nor are the relative stabilities of these compounds at comparatively high temperatures in entire accord with Baeyer's views. For instance, Berthelot (*3*) found that trimethylene is almost completely broken down at 550°C., the chief resultant product being the presumably less stable propylene (methyl dimethylene). Propylene heated to 550°C. undergoes no change.

Ingold and his collaborators (*4*) have modified the original concept by assuming that the "normal" angle of divergence of valency bonds postulated by Baeyer (109° 28′) applies only to quaternary carbon, and by calculating a slightly different "normal" angle for secondary carbon, which

is the essential element of the polymethylene rings. Further deviations in the "normal" angle are assumed to account for the influences of substituent groups upon the chemical and thermal properties of saturated rings. While these modifications suffice to bring the strain theory into closer accord with experimental facts in so far as polymethylene rings are concerned, they do not reconcile the anomalies inherent in the behavior of the first member of the cyclic series, ethylene (dimethylene).

Furthermore, if ease, or probability, of formation of a compound be taken as evidence of stability (in the sense of possession of a low "strain" factor) it is evident that Baeyer's hypothesis serves as a probability principle. In fact it is perhaps in this aspect that Baeyer's views have been of greatest utility to organic chemists, as tending to indicate what compounds might exist and what reactions might take place. From this standpoint, however, one without benefit of practical experience would be strongly inclined to deny the possibility of existence of ethylene or, indeed, of any of the olefines. Certainly Baeyer's hypothesis alone would not lead one to expect that the elimination of HI from normal butyl iodide by means of alcoholic potash would result in the formation of the presumably unstable two-membered ring derivative, butylene, to the total exclusion of the supposedly more stable four-membered ring, tetramethylene.

However, even if ethylene and its derivatives actually behaved as special cases of the ring compounds the hypothesis would be of very limited utility when applied exclusively to the olefines. It offers little basis for differentiation between individual bonds of the ethylene type, for the prediction of the course of directed addition at the double bond, for explanation of the relative ease with which various addition reactions take place, or the relative stabilities of various addition products.

Thiele's Hypothesis. Thiele (*5*) employed the hypothesis, later revised by Hinrichsen (*6*) of "partial free valencies." Practically speaking there is little significant difference between the concepts of Baeyer and Thiele. The two schemes differ chiefly in the symbolism employed to represent them. Therefore, since Thiele's hypothesis is subject to the same limitations of utility which we have pointed out in connection with Baeyer's hypothesis, we shall not consider it further here.

Empirical Rules Concerning Addition of Reagents at Unsymmetrical Double Bonds

The attempt to arrive at some generalization more useful in the description or prediction of double-bond reactions has led to the formulation of several empirical rules.

Markownikoff's Rules. Thus Markownikoff (*7*) stated that, in the addition of halogen acids to unsymmetrical olefines, the halogen attaches itself

to the least hydrogenated carbon atom, and he cited as examples: propylene, the butylenes, and the amylenes.

$$H_2C{:}CH(CH_3) + HI \longrightarrow H_3C{\cdot}CH(CH_3)I$$
$$H_2C{:}C(CH_3)_2 + HI \longrightarrow H_3C{\cdot}C(CH_3)_2I$$
$$H_2C{:}CH(C_2H_5) + HI \longrightarrow H_3C{\cdot}CH(C_2H_5)I$$
$$H_2C{:}CH(i\text{-}C_3H_7) + HCl \longrightarrow H_3C{\cdot}CH(i\text{-}C_3H_7)Cl$$
$$H_2C{:}CH(n\text{-}C_3H_7) + HI \longrightarrow H_3C{\cdot}CH(n\text{-}C_3H_7)I$$

Markownikoff further stated that in the addition of a halogen acid to "vinyl chloride, chloropropylene, and other analogs," the halogen always adds to the carbon atom which already carries a halogen atom.

$$H_2C{:}CHBr + HBr \longrightarrow H_3C{\cdot}CHBr_2$$
$$H_2C{:}CHBr + HI \longrightarrow H_3C{\cdot}CHBrI$$
$$H_2C{:}C(CH_3)Cl + HI \longrightarrow H_3C{\cdot}C(CH_3)ClI$$
$$H_2C{:}CHI + HI \longrightarrow H_3C{\cdot}CHI_2$$

In a later paper (*8*) Markownikoff combined and amplified his rules as follows:

Lorsqu' à une molécule non saturée C_nH_mX s'ajoute un autre système moléculaire YZ à une température basse, l'élément ou le groupe le plus négatif Y se combine avec l'atome de carbone le moins hydrogéné, ou avec celui qui était dejà en liaison directe avec quelque élément négatif; mais à des températures comparativement plus hautes, c'est l'élément Z, qui se fixe sur le carbone le moins hydrogéné, c'est-à-dire que, pour les mêmes substances, la réaction prend une marche tout a fait opposée à la premiere.

Saytzeff's Extension of Markownikoff's Rules. Saytzeff (*9*) extended Markownikoff's rules to cover the case of an ethylene compound containing two equally hydrogenated carbon atoms, one of which carries a methyl group and the other a longer aliphatic radical. Saytzeff declares that the halogen of the halogen acid will attach to the carbon atom bearing the methyl group.

$$(H_5C_2)CH{:}CH(CH_3) + HI \longrightarrow (H_5C_2)H_2C{\cdot}CH(CH_3)I$$

This rule is sometimes stated to the effect that in the case of an unsymmetrical olefine containing two equally hydrogenated carbon atoms the halogen will add to the carbon atom carrying the shorter chain.

If the unjustifiable attempt (never sanctioned by Markownikoff himself) is made to apply Markownikoff's rule to miscellaneous olefine derivatives as well as to the hydrocarbons themselves and their halogen derivatives, exceptions are encountered, as, for instance, in the case of acrylic (*10*) and ethylidenepropionic (*11*), (*12*) acids.

$$H_2C{:}CHCOOH + HCl \longrightarrow ClH_2C{\cdot}CH_2COOH$$
$$(H_3C)HC{:}C(CH_3)COOH + HBr \longrightarrow Br(H_3C)HC{\cdot}CH(CH_3)COOH$$

Upon the basis of rather slender evidence Ipatieff (*13*) achieved a broader statement of the facts, for he believed that the natures of the radicals

linked to the ethylene carbon atoms, the nature of the solvent employed, and the temperature at which the reaction is conducted all play a part in determining the position taken by the halogen. He did not, however, attempt to state specifically the influences of these various factors in directing the addition of halogen acids.

Previous Hypotheses Attempting to Describe or Predict Directed Addition at the Double Bond

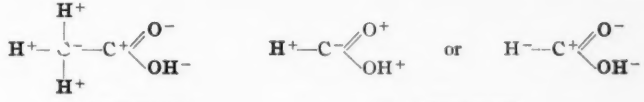
It would be undesirable to attempt, within the scope of a paper of this kind, an exhaustive résumé of all attempts to describe the course of directed addition reactions at ethylene double bonds and to arrive at a basis for predicting the courses of unknown additions. We shall confine ourselves, therefore, to brief comment upon several representative systems exemplifying the trends of thought which have attracted sufficient attention to receive wide discussion among chemists and to make their way into some of the textbooks (*14*).

THE CONCEPT OF ALTERNATE LATENT POLARITIES

Lapworth has advanced an explanation of the behavior of substituted olefines based upon his concept of "alternate latent polarities" (*15*). The alternate latent polarities attributed to the individual carbon atoms of a chain are ascribed to the influence of "key atoms," or groups, attached to the end carbon atoms of the chain. The principal negative key atoms are assumed to be bivalent oxygen and tervalent nitrogen, although the effectiveness of the halogens is also conceded; hydrogen is assumed to be a moderately effective positive key atom. The manner in which key atoms are supposed to induce alternate latent polarities is indicated herewith:

$$\bar{O}{=}\overset{+}{C}{-}\bar{C}{-}\overset{+}{C} \qquad\qquad \bar{N}{\equiv}\overset{+}{C}{-}\bar{C}{-}\overset{+}{C}$$

It is obvious that in employing this system one may sometimes arrive at different results, depending upon which end of the chain is selected as the starting point. If one arrives at the same sign for a given carbon atom by calculating from either end of the chain the key atoms are said to act "homogeneously." If discordant results are obtained they are said to act "heterogeneously." The following examples will serve to illustrate. Here **O** and **OH** may be regarded as the negative key groups and **H** as the positive key atom.



(Homogeneous) II (Heterogeneous)

Cuy (*16*) has advanced a more sweeping hypothesis of alternating polarities in which he postulates that "carbon atoms in a chain tend to assume alternately positive and negative charges," and has cited a number of experimental examples in support of it.

Since all hypotheses involving the assumption of alternate polarities suffer the same fundamental defects, we shall discuss Cuy's views as representative.

DEFICIENCIES OF THE CONCEPT OF ALTERNATE POLARITY

We believe it unfortunate that the notion of alternating polarities should have attracted such wide attention as to make its way into textbooks (*17*) for, since it has in some instances been presented in terms of electrons, its weaknesses have been employed as arguments against the use of the electronic concept in the teaching of organic chemistry.

This hypothesis has, of course, the obvious practical limitation that it frequently leaves one in considerable doubt as to the method of assigning polarities. Thus, Cuy is able without hesitation to assign polarities to carbon chains containing an *odd* number of carbon atoms, but is in difficulty immediately if the chain contains an *even* number of carbon atoms. For instance, he says that "an unsaturated carbon chain with an even number of carbon atoms (when treated with a halogen acid) may give one or both of the possible addition compounds." On the basis of the hypothesis which we desire to present later in this paper, there is no necessity for such vagueness in prediction.

The concept of alternating polarities is, however, open to the much more serious charges that it is based in part upon faulty or faultily interpreted experimental evidence, as has been shown in the able paper by Lucas and Jameson (*18*), and that the arguments advanced in favor of it involve some rather loose reasoning.

An outstanding example of the latter defect, cited by Lucas and Jameson, but not discussed in detail by them, is the emphasis laid by Cuy upon the alternating character of the melting-point curves of homologous series of acids. Verkade, Coops, and Hartman (*19*) have pointed out that oscillation of values of physical constants between odd and even members of homologous series of fatty acids has been observed in the cases of the following properties:

1. Melting points
2. Heats of crystallization (*20*)
3. Heats of combustion of crystalline acids (*21*)
4. Molecular volumes of crystalline acids (*22*)

No well-defined oscillation of values has, however, been detected in sufficiently accurate determinations of the following properties:

5. Boiling points
6. Molecular refractions of liquid acids (*23*), (*24*), or esters
7. Heats of combustion of liquid acids or esters (*25*)
8. Molecular volumes of liquid acids (*22*)
9. Any of the properties of the (liquid) dimethyl esters of solid acids of the saturated dicarboxylic series (*24*)

It is evident from the foregoing tabulation that oscillation of values of physical constants is a phenomenon associated with the crystalline state of matter, rather than with the electrostatic properties of the individual molecule. Beutler (*26*), as well as Garner and Randall (*20*), has pointed out that carbon compounds containing an even number of carbon atoms should crystallize with higher symmetry, and hence would be expected to have relatively higher lattice energies and consequently higher melting points, than compounds containing an odd number of carbon atoms. Müller (*27*) has presented the same view and has correlated it in some detail with actual X-ray data obtained by himself and Shearer (*28*). [See, also, Malkin (*131*).]

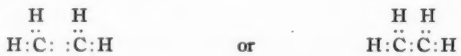
These considerations seem adequate to dispose effectively of the concept of alternate polarities, and we have discussed this hypothesis at length chiefly because it seems to us to be retarding rather than aiding progress toward the formulation of a sound theoretical basis for organic chemistry.

Further evidence that the points we have just discussed may be stressed with profit is found in the fact that even the most able and prominent organic chemists sometimes fail to take them into account. For example, in a recently published paper (*29*), conclusions are drawn as to the comparative effects produced upon the "lability" of a carbon-to-carbon bond in malonic acid derivatives, $RHC(COOH)_2$, by different substituent alkyl radicals. The study consists in determining the temperatures of decomposition of the various derivatives by a method which is not entirely immune to criticism. The real point of our comment, however, lies in the fact that the decomposition temperatures and the melting points of five out of six of the derivatives studied, as determined by these investigators, coincide within the limits of experimental error. Hence the chemical characteristics of the molecules (which the investigators hoped to probe) are obscured in this case by the symmetry characteristics of the respective crystal lattices. Significant studies of this kind can be made only when molecules are investigated in comparable states; *i. e.*, when *intra*-molecular forces and energies, as distinct from *inter*-molecular forces and energies, are measured.

The Lewis Concept of the Double Bond and Some Elaborations Thereupon

The electronic concept of the double bond advanced by Lewis (*30*) and elaborated by Carothers (*31*) and Lucas (*18*) does not involve the notion of

alternate polarity. The original form of the Lewis representation of the double bond may be considered as somewhat in the nature of a translation of the ideas of Baeyer and Thiele, respectively, into the more modern terminology of shared electron pairs. Accordingly, Lewis writes for ethylene:

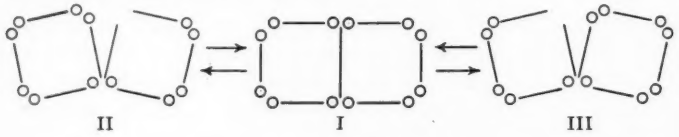


As Lewis himself points out, neither picture is entirely satisfactory, and he is inclined to believe that the actual state of affairs must be intermediate between those depicted by the foregoing formulas.

However, it is with the extension and application of the Lewis idea that we have mainly to do. The hypotheses of Carothers, of Lucas, and of the present authors may be said to proceed somewhat divergently from this common origin. We shall, therefore, touch upon their ideas but briefly at this point and shall discuss them further, by way of comparison, in connection with the presentation of our own views.

CAROTHERS' POSTULATE OF ACTIVE AND INACTIVE FORMS IN EQUILIBRIUM

We are reluctant to endorse Carothers' view that unsymmetrical unsaturated compounds exist in one inactive and one or both of two active forms and that the double bond in the three cases may be represented in accordance with the octet theory as follows:



Forms II and/or III (the active forms) are assumed by Carothers to be capable of only momentary existence and to be in equilibrium with the inactive form so that the concentration of the active form or forms is always small. In our opinion (which we shall elaborate at a later point in this discussion) there is no real evidence for the assumption that an inactive form exists. When two radicals attached to the two carbon atoms of the double bond differ but slightly in electronegativity it is possible for the electro-isomeric forms II and III to co-exist but we do not assume that they are at any time in equilibrium, either through form I or directly. We believe that, while it is possible to transform one electro-isomer into another, the change is accompanied by a change in the energy content of the system. We shall discuss the question of electro-isomerism more fully in connection with our views concerning the formation and nature of the double bond.

SOME DETAILS OF THE LEWIS AND LUCAS VIEW

The views of Lewis and Lucas differ from our own in two fundamental particulars—firstly, in the method of assigning relative electronegativities* to simple organic radicals, and, secondly, in postulating the effects of substituted radicals upon the electronegativities of derived groups.

For instance, Lucas bases his belief that the methyl radical is more electronegative than the ethyl radical (which coincides with our own) upon the fact that the ionization constant (K_α) for acetic acid is greater than that for propionic acid. Likewise, Lewis states that "hydrogen is more negative than a methyl radical but more positive than a phenyl radical. Methyl alcohol is a weaker acid than water; phenol is a stronger acid." If rigidly applied according to the methods of Lewis and Lucas this argument leads to an impassé, for, in accordance with this notion, formic acid should have a lower ionization constant than benzoic acid, while the contrary is the fact. (K_α for benzoic acid is 6.6×10^{-5}; for formic acid, 2.14×10^{-4}.)

However, we now believe that the so-called ionization or dissociation constant is not by any means a simple measure of the tendency of the acid molecule to release protons, and that other factors, such as the properties of the solvent (both protophilic and associative) and properties of the acid anion other than electronegativity, may play a considerable and often a predominant part** (*32*). Hence it seems wiser to place no great reliance upon this method of estimating the relative electronegative characters of organic radicals.

The present authors believe that the relative electronegativities of radicals can be determined definitely only by such direct experimental means as have been described in the first article of this series (*33*) and elsewhere (*34*), (*35*). It is possible, of course, to arrive at some intelligent estimates by inference from chemical data, but great care must be exercised to avoid drawing unwarranted conclusions.

The second essential point upon which the views of the present authors differ from those of Lewis and Lucas concerns the electronic shifts induced when a comparatively electronegative atom or radical is substituted for one or more hydrogen atoms in a methyl radical. Whereas Lewis and Lucas both assume that, when one electron pair is shared with a comparatively electronegative group, the resultant substituted methyl radical should be more electronegative, our postulate may be worded thus: so

* It will be recalled that we have defined the "electronegativity" of a radical as the degree of its attraction for electrons. Thus a strongly electronegative radical has a strong attraction for electrons; a weakly electronegative radical attracts electrons but weakly.

** These factors are particularly significant in the case of acids because of the unique nature of the acid cation, which consists of a lone proton.

far as the substituted methyl radical is concerned, when one or more electron pairs are shared with the carbon nucleus by comparatively electronegative substituent atoms or radicals the resultant radical should be less electronegative. We have already discussed this principle in the first article of this series and it has been employed to explain the formation of "free radicals" (*33*), (*35*).

If Lewis and Lucas were correct in their assumption the benzyl radical should be more electronegative than the methyl radical, for the comparatively electronegative phenyl group should draw the opposite electron pair closer to the carbon nucleus (Figure 1).

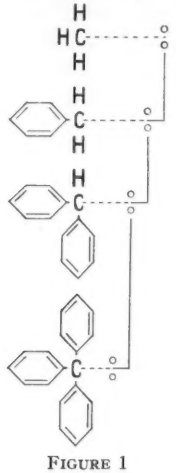


FIGURE 1

According to our view, however, the opposite should be the case (Figure 2).

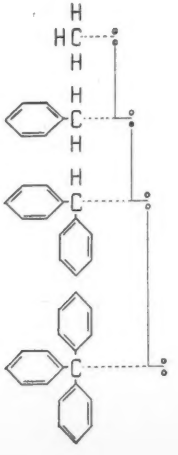
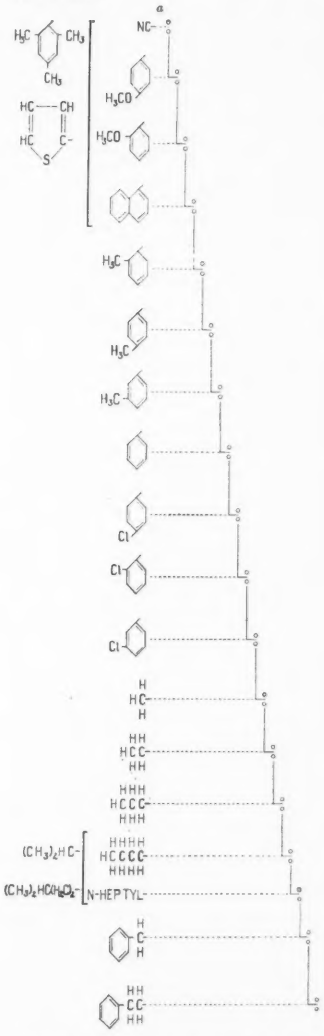


TABLE I.—THE RELATIVE ELECTRONEGATIVITIES OF SOME ORGANIC RADICALS*



* The radicals to the left of the brackets have not been precisely placed as yet. It is known that they fall within the respective ranges indicated by the brackets. An error in this table as it appeared in the first article of this series (*33*) is here corrected—namely, the transposition of the phenyl and *p*-chlorophenyl radicals.

[a] From silver cyanide.

As a matter of fact, the benzyl radical has been shown experimentally to be much *less* electronegative than the methyl radical. (See Table I.)

In justice to Lewis and in illustration of the breadth of his viewpoint and his wide knowledge of experimental facts, we desire to insert at this point notice of a fact which has escaped the attention of the present authors up to the time that this paper was actually on the press, and which has apparently been overlooked by many. Lewis did not, as we in common with numerous other authors have previously assumed, irrevocably commit himself to the view outlined and ascribed to him in the preceding paragraphs, as the following quotation (*177*) demonstrates:

> During the whole course of my investigations relating to the structure of molecules a very interesting question has constantly recurred to which I feel unable to give a definite answer. In our discussion of the electrochemical properties of substances we have assumed that if one pair of electrons were drawn away from an atom in a certain direction by an element striving for sole possession of the bonding pair, then the remaining pairs of that and neighboring atoms would be drawn in the same direction by electrostatic forces. This, however, would place the octet as a whole in an unsymmetrical position with respect to the atomic kernel, and the question is whether we may not occasionally meet with just the opposite phenomenon in which the drawing out of one or more pairs from the atomic center might lead to a withdrawal of the remaining pairs, in such manner as to result in a symmetrical tetrahedron about the kernel. . .
>
> Thus if the three hydrogens of methyl alcohol are replaced by phenyl groups these will draw three pairs of electrons away from the carbon atom, and if we were to assume that the remaining pair, which is the bond to the hydroxyl group, were forced away from the carbon atom at the same time, it might in this way be possible to account in part for the notably basic properties of triphenylmethyl carbinol which we recently considered.

The reader is invited to examine Bullard's (*164*) experimentally determined table of electronegativities in which the following order of decreasing electronegativity is adduced: phenyl > benzyl > methyl > ethyl. Bullard's conclusions are based upon his own experimental results (*164*), together with those of Kraus and Bullard (*165*), Kipping and Smith (*166*), and of others whom he cites, in the decomposition of organic derivatives of stannane by means of bromine and iodine (*which are oxidizing agents*). It should be noted that two entirely distinct effects can take place when such organo-metallic compounds are treated with halogens; namely, (1) the oxidation of an organic radical with subsequent cleavage of a carbon-to-metal bond, and (2) the simple cleavage of a carbon-to-metal bond. It is essential to employ a splitting reagent which performs the latter of these functions selectively (*e. g.*, a halogen acid or other non-oxidizing reagent) if valid conclusions concerning relative electronegativities are to be drawn. When the experiments cited by Bullard are performed with HCl and other non-oxidizing reagents, the order of electronegativity advanced by us is

substantiated precisely (*167*). This fact is further demonstrated in a recent paper by Kipping (*168*) who reports that tribenzylethylstannane, when treated with HCl, gives tribenzyltin chloride and ethane—in perfect agreement with the relative positions in Table I assigned by us to the benzyl and ethyl radicals.

In addition to further examples which we shall cite as we proceed, an interesting check upon the validity of this view is furnished by the recent determination of dissociation constants of derivatives of triphenylmethyl chloride in liquid SO_2 by Ziegler and Mathes (*36*). The reader should note that what we have said of acid dissociation constants applies in some measure to compounds of this type also, and that the dissociation constant is not a direct quantitative measure of the strength (or weakness) of the carbon-to-chlorine bonds in these compounds. However, with compounds of this type it doubtless furnishes a qualitative indication.

It is recorded in Table I that the *p*-methoxyphenyl radical is considerably more electronegative than the phenyl radical. On the other hand, the *p*-nitrophenyl radical has been found to be less electronegative than the phenyl radical. The successive changes in electronegative character which we would postulate as induced in the triarylmethyl radicals by the introduction of these substituents are indicated in the left-hand column of the tabulation below.* The values of K_{100} determined by Ziegler and Mathes for the chlorides are recorded in the corresponding right-hand column.

RADICAL	K_{100}
$(p\text{-}O_2NC_6H_4)_2PhC$----:	$2\text{–}3 \times 10^{-9}$
$(p\text{-}O_2NC_6H_4)Ph_2C$----└:	4.5×10^{-8}
$(p\text{-}MeOC_6H_4)(p\text{-}O_2NC_6H_4)_2C$-----└:	3×10^{-6}
Ph_3C-------└:	1×10^{-4}
$(p\text{-}MeOC_6H_4)(p\text{-}O_2NC_6H_4)PhC$---------└:	2×10^{-3}

On the basis outlined we would expect the carboxyl radical to be *very weakly* electronegative, and such its reactions show it to be. To cite but one example—if the carboxyl radical were highly electronegative, as Lucas assumes it to be, the union of two carboxyl radicals should give rise to a very stable carbon-to-carbon bond.** In the case of oxalic acid, however, the carbon-to-carbon bond has rather low stability, for it is ruptured by very moderate heating.

It will be more convenient to defer further discussion of the Lucas views until those of the present authors have been presented, and to consider the specific applications of the two hypotheses to bonds of the ethylene type comparatively.

* The representation is not intended to be in any sense quantitative. It indicates merely a relative order among the compounds listed.

** For a discussion of the relative stabilities of carbon-to-carbon bonds see the first article of this series (*33*).

The Authors' Concept of the Formation and Nature of the Ethylene Bond

It may be well to introduce our discussion with the statement that in developing our hypothesis we have chosen to regard the double bond as composed of a normal single bond with which is associated another single bond of rather exceptional character. Throughout we shall for the most part ignore the original carbon-to-carbon bond which we designate as "normal," and shall center our attention upon the extra electron pair which constitutes the second and peculiar member of the double bond. In so doing we do not imply *that we are presenting an actual picture of molecular "realities";* the molecular diagram which we shall employ receives all the justification it requires from its simplicity and its adequacy as a working hypothesis.

The extra electron pair, then, is considered to be *shared* by the two carbon atoms which are joined by the double bond, but to be more "loosely" held than is the electron pair which constitutes the original single bond. In other words, the sharing is accomplished in *outer energy levels*. Setting aside the question whether we are justified, otherwise than by considerations of expediency, in attributing this electronic displacement solely to one electron pair, let us examine the evidence which indicates the probability of such a displacement.

HEATS OF COMBUSTION OF ETHYLENE COMPOUNDS

An earlier paper by one of us and Sher (*37*), discusses the correlation of heat-of-combustion data with the electronic constitution of various organic bonds. The principles involved were again outlined in the first article of this series (*33*) and a more complete statement has been set forth in a paper by one of us (*38*). For the sake of convenience in reference those principles are briefly reiterated here.

For our immediate purpose the determination of the heat of combustion of a compound may be considered as the measurement of the energy liberated when the bonding electrons are transferred by a quantitative process from a system of unknown energy levels to a standard reference state. Combustion, is, of course, the quantitative reaction employed, and the electronic distribution which prevails in CO_2 constitutes the standard reference state.

It may be considered that the quantity of heat liberated in the combustion of ethane is expressible by means of two terms of opposite sign. The positive and larger of these terms, which we may call Z, represents the work done *by* the electrons in moving into an inner energy level of the oxygen atom.

The smaller and negative term, which we may call Y, represents the work which must be done *on* the electrons in displacing them away from the carbon nucleus. The observed heat of combustion may be called X,

which is equal to $Z-Y$. *It is evident, therefore, that if the electrons are already displaced somewhat farther from the carbon atoms than they are in the case of ethane, ...the quantity Y becomes smaller in value whereas Z remains constant. The net observed heat, X, then becomes larger* (*33*).

The formula which may be used to calculate the heats of combustion of ethane compounds is:

$$Q = 26.05N \text{ kg. cal.}$$

where Q, the mol heat of combustion, is analogous to X, and N is the number of electrons in the molecule. For ethylene derivatives, however, we must employ the equation:

$$Q = 26.05N + 13n \text{ kg. cal.},$$

where n is the number of double bonds (except for conjugated systems). Hence it is evident that the quantity which we have designated as Y above is smaller in the case of ethylene derivatives than in the case of aliphatic hydrocarbons, indicating an outward displacement of electrons. This displacement we find it convenient to attribute to the second electron pair of the double bond.

It is self-evident that the exact quantitative degree of displacement will be influenced by the net resultant effect of any substituent radicals attached to the ethylene carbon atoms. The value, 13 kg. cal. per mol, is merely the best average value for the aliphatic ethylene compounds here recorded. Table II is taken from a paper by one of us (*38*).

TABLE II

Heats of Combustion of Aliphatic-Ethylene Compounds.* ($Q = 26.05N + 13n$)

Formula	*Name*	*N*	*Kg.-cal. (calc. to liquid state)*	*Kg.-cal. (observed)*	*Literature*
C_2H_4	Ethylene (v)	12	325.6	345.4	(*156*)
				331.6**	(*157*)
C_3H_6	Propylene (v)	18	481.9	490.2	(*157*), *cf.* (*158*)
C_4H_8	Isobutylene (v)	24	638.2	647.2	(*157*)
C_5H_{10}	Amylene (1)	30	794.5	803.4	(*159*), *cf.* (*160*)
C_5H_{10}	Trimethylethylene (v)	30	794.5	803.6	(*157*)
	Trimethylethylene (1)	..	.....	796.0	(*161*)
C_6H_{12}	Hexylene (1)	36	950.8	952.6	(*161*)
C_6H_{10}	Diallyl (v)	34	911.7	928.1	(*157*)
				903.4	(*162*)
C_8H_{16}	Diisobutylene† (1)	48	1,263.4	1,252.4	(*163*)
$C_{10}H_{20}$	Diamylene (1)	60	1,576.0	1,582.2	(*159*)
$C_{12}H_{24}$	Triisobutylene‡ (1)	72	1,888.6	1,858.3	(*163*)

* It should be noted that all of these calculations are based upon the combustion of liquid compounds. For compounds in the gaseous state the heat of vaporization should be subtracted from the observed heat of combustion before comparison is made with the calculated value.

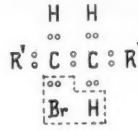
** Thomsen's value is probably more reliable than the higher value of Mixter.

† $(CH_3)_2CHCH{:}CHCH(CH_3)_2$.

‡ $(CH_3)_2CHCCH_2CH(CH_3)_2{:}CHCH(CH_3)_2$.

THE FORMATION OF THE ETHYLENE BOND

Let us approach our consideration of the ethylene bond anew by way of an examination of one of the general methods employed in its formation—namely, the removal of the elements of a halogen acid from an alkyl halide by means of alcoholic potash. The mechanism of this reaction may be plausibly characterized as the removal of the halogen ion, followed or accompanied by a restoration or preservation of the electrical neutrality of the molecule through the elimination of a hydrogen ion.



Thus the structure of the unsaturated molecule at the instant of formation may be indicated roughly as follows:

(I)

which may or may not be the most stable structure for a given unsaturated derivative.

In the light of the principles determining the electronic influence of substituent groups which we have already touched upon, it is evident that three possibilities present themselves at the instant of formation of the unsymmetrical unsaturated molecule.

1. If the radical, R′, is *decidedly more* electronegative than the radical, R″, the structure depicted above as (I) would represent the stable form.

2. If the radical, R′, is *decidedly less* electronegative than the radical, R″, the structure represented below as (II) would be the stable form and, *under the experimental conditions ordinarily prevailing in the preparation of unsaturated derivatives*, rearrangement to that form would immediately take place.

(II)

3. If the radical R′, is but *slightly less* electronegative than the radical, R″, the compound of structure (I) may exist but the molecule, under the influence of heat or light or of other environmental factors (*e. g.*, the solution medium), will tend to rearrange to the more stable structure (II). It is among compounds of this type that electro-isomerism may be anticipated. We shall have occasion to revert to the subject of electro-isomerism

at a later point in this discussion. Incidentally, the reader will note that forms (I) and (II) correspond to the "active forms" of Carothers (*31*). It is already fairly obvious why the present authors postulate no "inactive" form; the reasons why no equilibrium between forms (I) and (II) is assumed will be developed further in this paper.

Directed Addition of Halogen Acids at Ethylene Bonds*

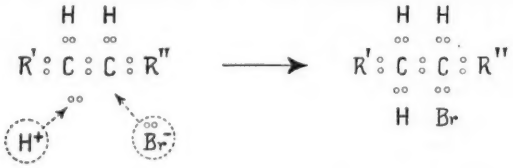
For the moment let us turn our attention to an examination of the utility of our hypothesis in describing the course of directed addition reactions at double bonds. At the expense of some repetition it may contribute to clarity to state our postulates in full here.

1. In *unsymmetrical* ethylene derivatives there is a definite "polarity" at the double bond; *i.e.*, in the terminology which we employ, the second pair of valence electrons constituting the double bond is held in an outer energy level of one carbon atom and in a relatively inner energy level of the other carbon atom. We have, for the most part, phrased our ideas in terms of energy levels rather than electronic orbits in order to avoid the appearance of setting up a mechanical molecular model, but it must be remembered that the terms are not strictly synonymous in all connections. It may be that our usual terminology misplaces the emphasis in this particular case—certainly the energy factor involved in an electronic displacement of this type must be exceedingly small. The reader may find it more illuminating to consider that these electrons move in orbits which cause them to spend a greater proportion of their time nearer to one carbon atom than to the other. That is to say that from a statistical standpoint their average space-time location is displaced away from one carbon atom and toward the other.

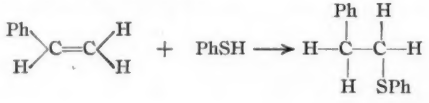
2. The relative "position" of the second pair of valence electrons is determined by the relative electronegativities of the radicals attached to the carbon atoms joined by the double bond. The electron pair is displaced *away from* the carbon atom bearing the most electronegative substituents and *toward* the opposite carbon atom.

* Recent and as yet unpublished experimental work by one of us (Kh.) and F. R. Mayo at the University of Chicago indicates that the factors which influence directed addition of halogen acids to very delicately balanced unsymmetrical olefines may be more numerous than the simple theory which we have here outlined recognizes. A final conclusion on this point must await the completion of a considerable amount of very carefully controlled experimental work—much more precise and painstaking work than any at present recorded in the literature. No doubt certain refinements or supplements to our present theory must be devised and tested to handle such special cases in a completely satisfactory manner. However, compounds of this type are comparatively rare and it seems reasonably probable that the theory in its present form will remain adequate to deal with the vast majority of addition reactions. At any rate we offer it as furnishing *the most satisfactory general picture of the facts at present recorded.*

3. When a halogen acid is added to an unsymmetrical ethylene derivative the halogen ion attaches to the carbon atom *from* which the second electron pair is farthest displaced; the hydrogen ion attaches to the carbon atom *toward* which the second electron pair is displaced.



In this connection the reader is cautioned that a sharp distinction should be made between ionic, molecular, and atomic additions. Thus if the work of Posner (*169*) and of Ashworth and Burkhardt (*170*) on the addition of mercaptans to olefine derivatives be regarded as analogous to HBr addition, for instance, the results appear anomalous. For example, the authors cited have reported the following addition:



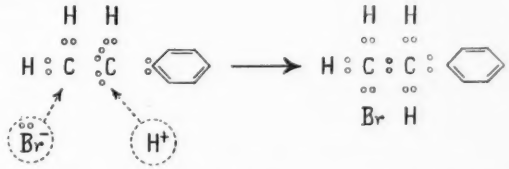
Under the experimental conditions employed phenyl mercaptan is undoubtedly undissociated. We believe that the reaction consists in the formation of an intermediate molecular addition compound of the sulfonium type, followed by a more or less complicated molecular rearrangement resulting in the final formation of the stable product isolated. Incidentally, the ability of the mercaptans to form molecular addition compounds is well known (*176*). This hypothesis is under experimental investigation by one of us (Kh.) at the University of Chicago at the present time.

4. When the radical, R″, is *distinctly more electronegative* than the radical, R′, the addition will take place almost quantitatively as indicated above. When the radicals, R″ and R′, *differ but slightly in electronegativity* two products may be expected, but the product which is ordinarily formed in greater proportion is the one which results from addition in accordance with the rule here set forth. In additions of this type, however, the previous history of the olefine and the experimental conditions of the addition reaction may influence the nature of the product to a marked degree.

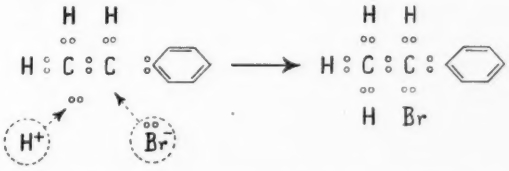
Let us now consider the application of these postulates to some specific reactions, at the same time comparing the views of Lucas with those of the present authors.

According to Lucas, styrene should have the electronic configuration in-

dicated below, and should add HBr to form phenylethyl bromide, according to the following reaction:



However, the product recorded in the literature (*39*), (*65*), (*170*) is that which would be predicted on the basis of the postulates of the present authors, namely, bromoethylbenzene.



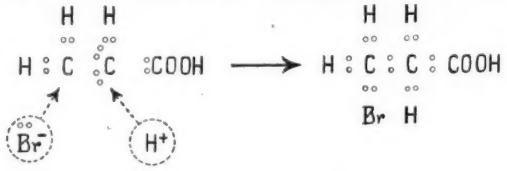
It should be recognized that a critical test of this hypothesis is possible only in the cases of substituents of which the relative electronegativities have been determined. It will be noted that the halogens have not as yet been given a place in Table I. While we would naturally assume from the position of the halogens in the electromotive series that they are strongly electronegative, and while (as a first approximation) we have treated them merely as electronegative radicals in this paper, the fact remains that they introduce complications at present not fully understood. Common experience shows, for instance, that there are significant differences between the behavior of fluorine and that of the other halogens as organic substituents. Work now in progress at the University of Chicago would incline us to say that fluorine acts very much like a highly electronegative organic radical, whereas the other halogens display variously modified behaviors. It may be that these differences are in some way connected with the fact that fluorine, like carbon, shares valence electrons with other atoms in its second (*l*) shell, whereas chlorine, bromine, and iodine share them in the third (*m*), fourth (*n*), and fifth (*o*) shells, respectively. No doubt in organic chemistry, as in inorganic chemistry, we shall eventually have to take account of the fact that the whole of chemical individuality is not summed up in the valence shell, but that the underlying kernel exerts a modifying influence.

In illustration of our point of view in this connection the following facts are rather striking. Whereas chlorine and oxygen are both regarded as strongly electronegative substituents, and one might anticipate on this

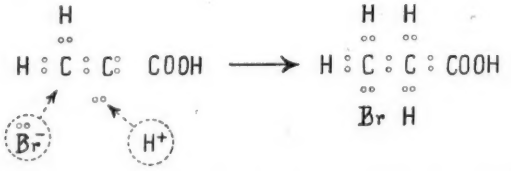
ground that the effects produced by them would be similar, or at least display a similar trend, it is found, as recorded in Table I, that the methoxyphenyl radicals are all *more* electronegative than the phenyl radical itself, while the chlorophenyl radicals are all *less* so.

Too extensive assumptions as to the probable effects of miscellaneous substituents should not be made *a priori*.

Returning to our comparison of the views of Lucas with those of the present authors it may be noted that since the two theories are mutually contradictory on two points, there is frequently a double negation in detail which leads to agreement in the ultimate prediction. Such an example is found in the case of acrylic acid. Lucas believes (1) that the carboxyl radical is highly electronegative, and (2) that the second electron pair is drawn closer to the carbon atom to which the most electronegative radical is attached. He would, therefore, expect the addition of HBr to acrylic acid to take place as indicated below.



Our own views, diametrically opposed to his on both of the foregoing points, would lead to the prediction of the same product, which is the one recorded in the literature (*40*).



From what we have said it is evident that unsymmetrically substituted ethylenes may be considered as falling into a number of types. Some of these may be classified as follows:

(*I*) *Monosubstituted ethylenes.*

(*a*) The substituent is definitely more electronegative than hydrogen. Styrene, already cited, is an example of this type. Such a compound gives rise to only one addition product when treated with a halogen acid, the halogen acid invariably attaching itself to the carbon atom which bears the substituent atom or radical.

(*b*) The substituent differs but slightly from hydrogen in electronega-

tivity. Allyl bromide is an example of this type. Halogen acid addition may result in the formation of one or both of two isomeric halides depending on the previous history of the ethylene derivative and the conditions under which the addition is conducted.

$H_2C{:}C(CH_2Br)H + HBr \longrightarrow H_2BrC{\cdot}C(CH_2Br)H_2$ and/or $H_3C{\cdot}C(CH_2Br)HBr$ (*41*), (*42*), (*43*), (*44*), (*45*), (*46*), (*47*).*

(*c*) The substituent is definitely less electronegative than hydrogen. Acrylic acid, already cited, is an example of this type. There is only one halogen acid addition product, the halogen being attached to the carbon atom which does *not* bear the substituent group.

II. Disubstituted ethylenes.

(*a*) The substituents are both more electronegative than hydrogen and both are attached to the same carbon atom. There is only one addition product and the halogen of the acid adds to the carbon atom bearing the substituents.

$$H_2C{:}C(CH_3)Br + HBr \longrightarrow H_3C{\cdot}C(CH_3)Br_2 \qquad (48)$$
$$H_2C{:}C(CH_3)(C_2H_5) + HI \longrightarrow H_3C{\cdot}C(CH_3)(C_2H_5)I \qquad (49)$$

(*b*) Of the substituents one is more electronegative and the other is less electronegative than hydrogen; they are attached to opposite ethylene carbon atoms. There is one addition product; the acid halogen adds to the carbon atom bearing the more electronegative substituent.

$$HPhC{:}C(COOH)H + HBr \longrightarrow HPhBrC{\cdot}C(COOH)H_2 \qquad (50), (51)$$

(*c*) Of the substituents, one is more electronegative and the other is less electronegative than hydrogen; both are attached to the same carbon atom. Either or both of the isomeric addition products may be expected, depending upon previous history of the olefine and *the experimental conditions of the addition.*

$H_2C{:}C(CH_3)(COOH) + HBr \longrightarrow H_3C{\cdot}C(CH_3)(COOH)Br$ and/or $H_2BrC{\cdot}C(CH_3)(COOH)H$ (*52*)

(*d*) The substituents are both more electronegative than hydrogen but nearly equal in electronegativity; they are attached to opposite carbon atoms. Halogen acid addition may result in the formation of either or both possible isomers, depending upon the factors already noted.

$H(CH_3)C{:}C(C_2H_5)H + HBr \longrightarrow BrH(CH_3)C{\cdot}C(C_2H_5)H_2$ and/or $H_2(CH_3)C{\cdot}C(C_2H_5)HBr$ (*39*), (*53*), (*54*), (*55*)

III. Polysubstituted Ethylenes.

With tri- and tetra-substituted ethylenes there is a mutual augmentation or diminution in the electronic effects of oppositely attached substituents,

* This addition is now being investigated in minute detail by one of us (Kh.) and F. R. Mayo, at the University of Chicago. In connection with this and the succeeding examples cited the reader is invited to keep in mind the remarks set forth in the footnote on p. 1719.

according to the principles already outlined for di-substituted derivatives. The following examples are illustrative:

$$H(CH_3)C{:}C(CH_3)_2 + HEr \longrightarrow H_2(CH_3)C{\cdot}C(CH_3)_2Br \quad (56), (57)$$
$$H(COOH)C{:}C(COOH)(CH_3) + HBr \longrightarrow H_2(COOH)C{\cdot}C(COOH)(CH_3)Br \quad (58)$$
$$H(CH_3)C{:}C(CH_3)(COOH) + HBr \longrightarrow HBr(CH_3)C{\cdot}C(CH_3)(COOH)H \quad (59), (60)$$
$$H(COOH)C{:}C(CH_3)_2 + HBr \longrightarrow H_2(COOH)C{\cdot}C(CH_3)_2Br \quad (61)$$
$$(COOH)(CH_3)C{:}C(CH_3)_2 + HBr \longrightarrow H(COOH)(CH_3)C{\cdot}C(CH_3)_2Br \quad (62)$$

It is evident that various other combinations of substituents are possible, but the foregoing examples should suffice to illustrate the reasoning employed in describing or predicting the course of halogen acid additions to unsymmetrical ethylene derivatives.

The main difficulty in predicting all types of addition reactions lies in our ignorance of the relative electronegativities of organic radicals. However, with two assumptions supplementary to Table I it becomes possible to reconcile our addition reactions at the double bond with the facts actually known. The first assumption is that alkyl or aryl radicals in general are more electronegative than hydrogen. Secondly, that if a methyl carbon atom has strongly electronegative substituent radicals attached to it the group as a whole may become equal to, or lower than, the hydrogen atom in electronegativity.

The first assumption is self-evident—it means that such groups as phenyl, methyl, ethyl, or naphthyl are more electronegative than the hydrogen atom, although it is quite conceivable that an overlapping may occur somewhere, as for instance in the case of normal aliphatic radicals longer than butyl, or of secondary or tertiary aliphatic radicals. In the second assumption we merely imply that since an electronegative radical attached to a methyl carbon atom decreases enormously the electronegative character of the group, it would tend to put us on the other side of the electronegativity of the hydrogen atom.

Thus, while the phenyl radical, a bromine, or a chlorine atom, or a hydroxyl group or oxygen atom are individually more electronegative than a hydrogen atom, when they become attached to a methyl carbon atom, as for example in the radicals, benzyl or bromomethyl or chloromethyl, they make these groups either less electronegative than hydrogen or almost equal in electronegativity to the hydrogen atom.

Further experimental examples are set forth in Table III. In offering this tabulation we caution the reader that much of the experimental work recorded in the literature is unreliable—particularly that performed in earlier years. Fractional distillation has frequently been employed to isolate products, and boiling points have been accepted as sufficient criteria for identification. That such methods of analysis are not to be trusted implicitly has been amply demonstrated. Hence it should be understood that many of the reactions tabulated are probably subject to revision.

Table III

Some Addition Reactions Recorded in the Literature*

The columns headed *L.* and *Kh. & R.* have reference to the hypotheses adopted by Lucas and by the present authors, respectively. The symbol, +, indicates, either that one product is predictable upon the basis of the respective hypothesis and that one and the same product is recorded in the literature, or that two products are predictable and two products are recorded in the literature. The symbol, −, indicates that one product is predictable and that one, but a different product is recorded in the literature. The symbol, $^1/_2$ ≐, indicates that one product is predictable, but that two are recorded in the literature; while the symbol, $^2/_1$ ≐, indicates that two products are predictable and that only one is recorded.

Ethylene Derivative	Acid	Product Recorded	L.	Kh. & R.	Literature
$H_2C{:}CHBr$	HCl	$H_3C{\cdot}CHBrCl$	−	+	(*63*)
	Conc. HBr (hot or cold)	$BrH_2C{\cdot}CH_2Br$ [1]	+	−	(*41*)
	Conc. HBr (cold)	$H_3C{\cdot}CHBr_2$ [1]	−	+	(*39*), p. 587
	HBr + $^1/_2$ vol. H_2O	$H_3C{\cdot}CHBr_2$ [1]	−	+	(*41*)
	Conc. HI (*63*) cold (*64*) hot	$H_3C{\cdot}CHBrI$	−	+	(*63*), (*64*)
$H_2C{:}CHPh$	HCl	$H_3C{\cdot}CHPhCl$	−	+	(*65*)
	HBr	$H_3C{\cdot}CHPhBr$	−	+	(*65*), (*170*)
$H_2C{:}C(CH_3)H$ (liquid)	HCl (liquid)	$H_3C{\cdot}C(CH_3)HCl$ [2]	+	+	(*66*), (*67*)
	HBr (liquid)	$H_3C{\cdot}C(CH_3)HBr$ [2]	+	+	(*68*)
	HI	$H_3C{\cdot}C(CH_3)HI$	+	+	(*69*), (*70*), (*71*)
$H_2C{:}C(C_2H_5)H$	HI	$H_3C{\cdot}C(C_2H_5)HI$	+	+	(*71*), (*72*), (*73*)
$H_2C{:}C(n\text{-}C_3H_7)H$	HI	$H_3C{\cdot}C(n\text{-}C_3H_7)HI$	+	+	(*71*), (*74*), (*75*)
$H_2C{:}C(i\text{-}C_3H_7)H$	HCl	$H_3C{\cdot}C(i\text{-}C_3H_7)HCl$	+	+	(*71*)
	HBr	$H_3C{\cdot}C(i\text{-}C_3H_7)HBr$	+	+	(*49*)
	HI	$H_3C{\cdot}C(i\text{-}C_3H_7)HI$	+	+	(*49*)
$H_2C{:}C(n\text{-}C_4H_9)H$	HI	$H_3C{\cdot}C(n\text{-}C_4H_9)HI$	+	+	(*75*)

* We have not included mercaptan additions for the reasons cited on p. 1720.

[1] This work is being repeated by one of us (Kh.) and F. R. Mayo, at the University of Chicago.

[2] Products chiefly as listed. Side reactions give rise to small amounts of hexyl halide, etc.

[3] Reboul (*77*) reports incomplete addition only.

[4] These compounds are being thoroughly investigated by one of us (Kh.) and F. R. Mayo, at the University of Chicago. We believe that these addition reactions constitute a critical test of our views as compared with those of Lucas. Upon the basis of the Lucas postulates only one product, the *1,3*-dihalide, is predictable. According to our views the product should vary with the conditions of the experiment. This has been found to be the case, and we have actually isolated quantitative yields of the *1,2*-dihalogen products (*47*).

Table III—(*Continued*)

Ethylene Derivative	Acid	Product Recorded	L.	Kh. & R.	Literature
$H(CH_2Cl)C:CH_2$	HCl	$ClH(CH_2Cl)C\cdot CH_3$ [3,4]	−	+	(*76*), (*77*)
		$ClH(CH_2Cl)C\cdot CH_3$ [4] + $H_2(CH_2Cl)C\cdot CH_2Cl$	$\frac{1}{2}\pm$	+	(*47*)
	HBr	$H(CH_2Cl)C\cdot CH_2Br$ [4] + $BrH(CH_2Cl)C\cdot CH_3$	$\frac{1}{2}\pm$	+	(*78*), (*47*)
$H(CH_2Br)C:CH_2$	HBr	$H(CH_2Br)C\cdot CH_2Br$ [4] and $BrH(CH_2Br)C\cdot CH_3$ as well as mixtures in various proportions	$\frac{1}{2}\pm$	+	(*41*), (*42*), (*43*), (*44*), (*45*), (*46*), (*47*)
$H(COOH)C:CH_2$	HCl	$H_2(COOH)C\cdot CH_2Cl$	+	+	(*40*)
	HBr	$H_2(COOH)C\cdot CH_2Br$	+	+	(*40*)
	HI (*79*) at 130°C.	$H_2(COOH)C\cdot CH_2I$	+	+	(*40*), (*79*)
$H_2C:C(CH_3)Cl$	HCl	$H_3C\cdot C(CH_3)Cl_2$	$\frac{2}{1}\pm$ [5]	+	(*80*)
	HBr	$H_3C\cdot C(CH_3)ClBr$	$\frac{2}{1}\pm$ [5]	+	(*81*)
	HI	$H_3C\cdot C(CH_3)ClI$	$\frac{2}{1}\pm$ [5]	+	(*82*)
$H_2C:C(CH_3)Br$	HCl	$H_3C\cdot C(CH_3)BrCl$	$\frac{2}{1}\pm$ [5]	+	(*83*)
	HBr	$H_3C\cdot C(CH_3)Br_2$	$\frac{2}{1}\pm$ [5]	+	(*48*)
	HI	$H_3C\cdot C(CH_3)BrI$	$\frac{2}{1}\pm$ [5]	+	(*84*)
$H_2C:C(CH_3)_2$	HCl	$H_3C\cdot C(CH_3)_2Cl$	+	+	(*85*), (*86*)
	HBr	$H_3C\cdot C(CH_3)_2Br$	+	+	(*87*)
	HI	$H_3C\cdot C(CH_3)_2I$	+	+	(*56*), (*88*), (*89*)
$H_2C:C(CH_3)(C_2H_5)$	HCl	$H_3C\cdot C(CH_3)(C_2H_5)Cl$	+	+	(*90*)
	HI	$H_3C\cdot C(CH_3)(C_2H_5)I$	+	+	(*49*)
$H_2C:C(CH_3)(t\text{-}C_4H_9)$	HI	$H_3C\cdot C(CH_3)(t\text{-}C_4H_9)I$	+	+	(*91*)
$H_2C:C(CH_2Cl)Cl$	HBr	$H_3C\cdot C(CH_2Cl)ClBr$ + $BrH_2C\cdot C(CH_2Cl)ClH$	$\frac{1}{2}\pm$ [6]	+	(*83*)

[5] According to the postulates of Lucas the substituents, halogen and CH_3, exert opposing influences upon the displacement of the second electron pair; hence two products are predictable upon the basis of their concept. According to our hypotheses these substituents exert concordant influences and only one product is predictable.

[6] This constitutes another critical case, for Lucas would definitely predict one product, whereas we predict two.

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[6] This constitutes another critical case, for Lucas would definitely predict one product, whereas we predict two.

Table III—(*Continued*)

Ethylene Derivative	Acid	Product Recorded	L.	Kh. & R.	Literature
$H_2C{:}C(CH_3)(COOH)$	HBr	$H_3C{\cdot}C(CH_3)(COOH)Br$ + $BrH_2C{\cdot}C(CH_3)(COOH)H$	+	+	(*52*)
	HI	$IH_2C{\cdot}C(CH_3)(COOH)H$	$\frac{2}{1}\pm$	$\frac{2}{1}\pm$	(*92*)
H(COOH)C:CHCl	HCl at 80–85°	$H_2(COOH)C{\cdot}CHCl_2$	$\frac{2}{1}\pm$[7]	+[7]	(*93*)
H(COOH)C:CHBr	HBr at 100°	$H_2(COOH)C{\cdot}CHBr_2$	$\frac{2}{1}\pm$[7]	+[7]	(*94*)
trans-H(COOH)C:CHPh	HCl	$H_2(COOH)C{\cdot}CHPhCl$ [8]	$\frac{2}{1}\pm$	+	(*50*)
	HBr	$H_2(COOH)C{\cdot}CHPhBr$ [9]	$\frac{2}{1}\pm$	+	(*50*), (*51*)
	HI	$H_2(COOH)C{\cdot}CHPhI$ [9]	$\frac{2}{1}\pm$	+	(*51*)
cis-H(COOH)C:CHPh	HCl	$H_2(COOH)C{\cdot}CHPhCl$ [9]	$\frac{2}{1}\pm$	+	(*50*)
	HBr	$H_2(COOH)C{\cdot}CHPhBr$ [9]	$\frac{2}{1}\pm$	+	(*50*)
α-H(COOH)C:C(CH$_3$)H	HBr (gas)	$H_2(COOH)C{\cdot}C(CH_3)HBr$	+	+	(*95*)
	HI	$H_2(COOH)C{\cdot}C(CH_3)HI$	+	+	(*96*)
β-H(COOH)C:C(CH$_3$)H	HI	$H_2(COOH)C{\cdot}C(CH_3)HI$	+	+	(*96*)
H(COOH)C:C(C_2H_5)H	HBr	$H_2(COOH)C{\cdot}C(CH_3)HBr$	+	+	(*97*)
H(COOH)C:C(*n*-C_3H_7)H	HBr	$H_2(COOH)C{\cdot}C(n\text{-}C_3H_7)HBr$	+	+	(*98*)
H(COOH)C:C(*i*-C_3H_7)H	HBr	$H_2(COOH)C{\cdot}C(i\text{-}C_3H_7)HBr$	+	+	(*99*)
H(COOH)C:C(*i*-C_4H_9)H	HBr	$H_2(COOH)C{\cdot}C(i\text{-}C_4H_9)HBr$	+	+	(*100*)
H(COOH)C:C(CH_2Ph)H	HBr	$H_2(COOH)C{\cdot}C(CH_2Ph)HBr$	+[10]	+[0]	(*101*)
H(CH_3)C:CHCl	HBr	$H_2(CH_3)C{\cdot}CHClBr$ + $BrH(CH_3)C{\cdot}CH_2Cl$ [11]	$\frac{1}{2}\pm$	+	(*91*), see also p. 484

[7] In view of the high temperatures employed, these data are of no critical significance.

[8] Very slight addition only.

[9] These constitute critical cases, for the postulates of Lucas would lead to the prediction of two products, whereas we predict only one.

[10] In accordance with either theory it is probable that the direction of this addition can be reversed (at least partially) under suitable experimental conditions.

[11] In the cold only traces of this isomer are formed; in the hot, somewhat more. The Lucas postulates would predict the formation of this isomer exclusively.

Table III—(*Concluded*)

Ethylene Derivative	Acid	Product Recorded	L.	Kh. & R.	Literature
$H(CH_3)C{:}CHBr$	HBr	$H_2(CH_3)C{\cdot}CHBr_2$ + $BrH(CH_3)C{\cdot}CH_2Br$	$\frac{1}{2}\pm$	+	(*102*)
$H(C_2H_5)C{:}C(CH_3)H$	HBr	$H_2(C_2H_5)C{\cdot}C(CH_3)HBr$ + $BrH(C_2H_5)C{\cdot}C(CH_3)H_2$	+	+	(*39*), (*53*), (*54*), (*55*)
	HI	$H_2(C_2H_5)C{\cdot}C(CH_3)HI$ [12]	$\frac{2}{1}\pm$	$\frac{2}{1}\pm$	(*75*), (*103*)
$H(CH_3)C{:}C(CH_3)_2$	HCl	$H_2(CH_3)C{\cdot}C(CH_3)_2Cl$	+	+	(*90*)
	HBr	$H_2(CH_3)C{\cdot}C(CH_3)_2Br$	+	+	(*56*), (*57*)
	HI	$H_2(CH_3)C{\cdot}C(CH_3)_2I$	+	+	(*71*)
$H(CH_3)C{:}C(CH_3)(C_2H_5)$	HI	$H_2(CH_3)C{\cdot}C(CH_3)(C_2H_5)I$	+	+	(*105*)
$H(COOH)C{:}C(COOH)(CH_3)$	HCl	$H_2(COOH)C{\cdot}C(COOH)(CH_3)Cl$	+	+	(*58*)
	HBr	$H_2(COOH)C{\cdot}C(COOH)(CH_3)Br$	+	+	(*58*)
$(COOH)(CH_3)C{:}C(CH_3)H$ (Tiglic acid)	HBr	$H(COOH)(CH_3)C{\cdot}C(CH_3)HBr$	+	+	(*59*), (*60*)
	HI	$H(COOH)(CH_3)C{\cdot}C(CH_3)HI$	+	+	(*60*), (*106*), (*107*)
$(COOH)(CH_3)C{:}C(CH_3)H$ (Angelic acid)	HBr	$H(COOH)(CH_3)C{\cdot}C(CH_3)HBr$	+	+	(*59*), (*60*)
	HI	$H(COOH)(CH_3)C{\cdot}C(CH_3)HI$	+	+	(*60*), (*106*), (*107*)
$H(C_2H_5)C{:}C(CH_3)_2$	HI	$H_2(C_2H_5)C{\cdot}C(CH_3)_2I$	+	+	(*105*), (*108*)
$H(i\text{-}C_3H_7)C.C(CH_3)_2$	HI	$H_2(i\text{-}C_3H_7)C{\cdot}C(CH_3)_2I$	+	+	(*109*), (*110*)
$H(t\text{-}C_4H_9)C{:}C(CH_3)_2$	HCl at 100°	$H_2(t\text{-}C_4H_9)C{\cdot}C(CH_3)_2Cl$	+	+	(*111*)
	HBr	$H_2(t\text{-}C_4H_9)C{\cdot}C(CH_3)_2Br$	+	+	(*111*)
	HI	$H_2(t\text{-}C_4H_9)C{\cdot}C(CH_3)_2I$	+	+	(*111*)
$H(COOH)C{:}C(CH_3)_2$	HBr	$H_2(COOH)C{\cdot}C(CH_3)_2Br$	+	+	(*61*)
$H(CH_3)C{:}C(C_2H_5)_2$	HCl	$H_2(CH_3)C{\cdot}C(C_2H_5)_2Cl$	+	+	(*112*)
$(COOH)(C_2H_5)C{:}CPhH$	HBr	$H(COOH)(C_2H_5)C{\cdot}CPhHBr$	$\frac{2}{1}\pm$	+	(*113*)
$(COOH)(C_2H_5)C{:}C(CH_3)H$	HBr	$H(COOH)(C_2H_5)C{\cdot}C(CH_3)HBr$	+	+	(*114*)
$Cl(COOH)C{:}C(CH_3)H$	Excess HCl at 100°	$HCl(COOH)C{\cdot}C(CH_3)HCl$	+	+	(*115*), (*116*)
$(COOH)(CH_3)C{:}C(CH_3)_2$	HBr	$H(COOH)(CH_3)C{\cdot}C(CH_3)_2Br$	+	+	(*62*)
	HI	$H(COOH)(CH_3)C{\cdot}C(CH_3)_2I$	+	+	(*62*)
$Br(COOH)C{:}C(CH_3)_2$	HBr	$HBr(COOH)C{\cdot}C(CH_3)_2Br$	+	+	(*117*)

[12] *Cf.*, however, Michael (*104*).

Keeping in mind the fact that the data collected in Table III cannot be regarded as infallible, it is nevertheless of interest to summarize the correlations and discrepancies between the predictions based on the postulates of Lucas and of the present authors, respectively, and the recorded experimental data. Leaving aside the addition of concentrated HBr to vinyl bromide, concerning which the experimental findings are at present mutually contradictory, it is to be noted that the predictions of the two theories are in complete agreement with each other and with the literature regarding fifty of the reactions listed. In five cases Lucas would predict the formation of a single product which is not the single product predicted by us nor recorded in the literature. Disregarding two high-temperature reactions, there are twelve cases in which the views of Lucas would lead to the prediction of two products, where we would predict one product; in all twelve cases one product is reported in the literature. There are seven cases in which the Lucas postulates would lead to the definite prediction of one product, whereas we would predict the probability of two; in six of these cases two products are recorded in the literature and in the seventh the product isolated is not that predicted by Lucas. In two cases where both theories would predict the probability (or at least the possibility) of two products, only one has been reported.

Ease of Addition at Ethylene Bonds and Relative Stabilities of Addition Products

In further consideration of the chemical behavior of ethylene derivatives, we may well devote a few paragraphs to a consideration of the relative ease with which sundry reagents add to olefine compounds, and of the relative stabilities of the corresponding addition products.

It is well known that the ease of addition of elementary halogens is in the order: chlorine > bromine > iodine; whereas for the halogen acids the reverse order prevails: HI > HBr > HCl. These facts are readily understandable upon the basis of the theory which we have here proposed.

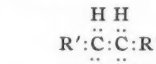
Let us first consider in detail the addition of an elementary halogen to an ethylene derivative. The essential prelude to, or the first stage in, the addition of a halogen molecule to an ethylene derivative molecule must be the capture of a sharing interest in an additional pair of electrons by the halogen molecule. (The additional pair of electrons subject to "capture" in this manner is, of course, the pair which we have designated as the second or "significant" member of the double bond.) To employ a different terminology, the halogen molecule must undergo what is in effect a species of reduction.*

* The reader will recall that reduction is defined as a gain of electrons; oxidation as a loss of electrons.

[12] *Cf.*, however, Michael (*104*).

Perhaps this point may be made more obvious by means of a slightly varied reiteration. Whatever may be the separate steps through which the addition takes place, we may adopt the thermodynamic point of view and consider initial and final states only. In the initial state the atoms which compose the halogen molecule are jointly and severally possessed of six pairs of unshared electrons and *one* pair of shared electrons.

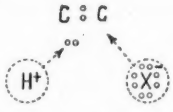
In the final state the halogen atoms are jointly and severally possessed of six pairs of unshared electrons and *two* pairs of shared electrons.



A (partial) reduction of the halogen molecule has taken place.

Apparently the ease and rapidity with which this essential operation is accomplished determines the ease and rapidity with which the entire addition reaction takes place. Hence it is to be expected that among the halogens the strongest oxidizing agent will be the most readily reduced and will therefore undergo addition with the greatest ease. This expectation is fulfilled by the experimental facts.

When the addition of a halogen acid to an ethylene derivative is considered, however, it is seen that the circumstances are somewhat different. Here we may suppose that the hydrogen ion associates itself with the extra electron pair and thus becomes attached to the carbon atom *toward* which the electron is displaced. For any given ethylene derivative this portion of the addition reaction takes place with equal facility regardless of which specific halogen acid is employed. The other stage of the addition consists in the attachment of the halogen ion (with its octet of electrons) to the carbon atom *away from* which the extra electron pair is displaced.



For this attachment to take place the halogen ion must give up to the carbon atom a sharing interest in one pair of electrons; *i. e.*, it must undergo what is in effect a species of partial oxidation. Naturally, the more electronegative the ion, the greater will be the difficulty with which this "oxidation" is accomplished. Hence it is inevitable that hydrochloric acid should add to ethylene derivatives less readily than hydrobromic acid, and hydrobromic acid less readily than hydriodic acid.

We have considered the addition of the various halogens and halogen acids to a given hypothetical ethylene compound. Let us now alter our point of view and consider the addition of a given reagent to various ethylene derivatives.

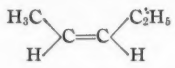
If the given addition reagent be a halogen, ease of addition is promoted by the presence of electronegative substituents in the ethylene molecule. Such substituents have displaced the second pair of electrons away from the carbon nuclei and therefore diminish the work which must be done by the halogen molecule in capturing a sharing interest in the electron pair.

It should be recognized in this connection, however, that ease of addition goes hand in hand with instability of the reaction product. Thus α-stilbene adds Br_2 readily and the product is stable at the melting point (*118*), (*119*), (*120*), but upon distillation it gives up Br_2 and HBr forming stilbene and monobromostilbene (*121*). When the two highly electronegative phenyl groups are attached to one carbon atom as in unsymmetrical diphenylethylene, (*122*), or when the ethylene molecule is loaded with additional electronegative substituents as in α,β-dimethylstyrene (*123*), in α-phenyl-β-methylstyrene (*123*), methylstilbene (*124*), (*125*), (*126*), or phenylstilbene (*127*), (*136*), Br_2 adds readily at low temperatures, but the products eliminate HBr at room, or slightly elevated, temperatures. The net result is the replacement of a hydrogen atom by a bromine atom, but it is significant that the substitution takes place through addition. The characteristic instability of the products resulting from addition of bromine to ethylene derivatives containing several highly electronegative substituents is undoubtedly the basis for the repeated statement that such derivatives as tetraphenylethylene do not add bromine (*128*), (*129*), (*130*).

Electronegative substituents in ethylene derivatives also conduce to ease of addition of halogen acids, for a carbon atom already bearing an electronegative substituent is able to share the bonding electron pair contributed by the halogen ion in comparatively outer energy levels. This again corresponds to relatively less work done in effecting the union. Hence it is not surprising that, whereas it is recorded that ethylene does not add HCl, isobutylene adds that reagent fairly readily (*85*), (*86*).

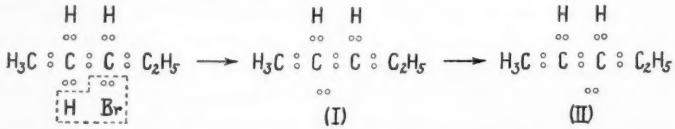
Indications of Electro-Isomerism

In our discussion of the formation of the ethylene bond we have already outlined the factors which may give rise to electro-isomerism. The original evidence in support of these views was obtained in the study of *2*-pentene. Lucas and Moyse (*53*) had reported that the addition of HBr to this olefine gives rise to a mixed product consisting of 22% *2*-bromopentane and 78% *3*-bromopentane. Since *2*-pentene may be considered as symmetrical ethylmethylethylene,



and since the methyl radical is slightly more electronegative than the ethyl radical, our rules of addition as originally formulated would lead one to expect a mixed product, but one in which the *2*-bromo compound should predominate. However, a repetition of the experimental work of Lucas and Moyse by one of us and Darkis (*39*) yielded results identical with theirs.

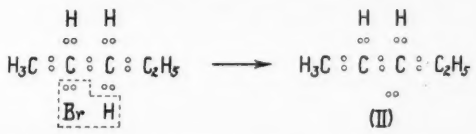
The idea then suggested itself that, since the *2*-pentene employed had been prepared by the removal of HBr from *3*-bromopentane, it might still be largely in the unstable form (I).



If this were true any "agitation" of the molecule through exposure to heat or light should facilitate electronic rearrangement into the more stable form (II). Accordingly samples of *2*-pentene, so prepared, were submitted respectively to heating at various temperatures and for various periods of time and to the light of a Mazda lamp for various periods of time. The relative proportions of *2*-bromo and *3*-bromo compounds in the products obtained upon subsequent addition of HBr indicated that electronic rearrangement is indeed facilitated by exposure to the light of an electric lamp or to temperatures of 80° to 160° in diffused daylight (*39*).

Further confirmation of this view was obtained from ultra-violet light absorption tests very kindly performed by Dr. B. H. Carrol of the U. S. Bureau of Standards and from the addition of HBr to samples of *2*-pentene which had been subjected to ultra-violet irradiation (*39*). A more detailed study of the ultra-violet absorption spectra of the electro-isomeric *2*-pentenes has since been made by Miss Carr (*132*). Sherrill, Otto, and Pickett (*54*) have made further studies on the addition of HBr to *2*-pentene, prepared from *3*-bromopentane and subjected to the action of sunlight or ultra-violet light, and have also investigated the influence of solvents upon the course of the directed addition.

Another very critical link in the chain of evidence has been supplied by Sherrill, Baldwin, and Haas (*55*) in the addition of HBr to *2*-pentene prepared from *2*-bromopentane. It is obvious from what we have already said that the elimination of HBr from *2*-bromopentane should yield the stable electro-isomer directly without the necessity of rearrangement, according to the following scheme:



The product obtained in the addition of HBr to *2*-pentene prepared in this manner is in confirmation of our views.

The combined conclusions set forth in the three papers just mentioned may be summarized as follows:

1. Pentene-*2*, prepared from *3*-bromopentane and carefully purified, adds HBr in a non-polar solvent such as carbon tetrachloride to give 98–99% of *3*-bromopentane. In glacial acetic acid it adds HBr to give 78% of *3*-bromopentane and 22% of *2*-bromopentane. Addition of Br_2 yields *2,3*-dibromopentane.
2. Sunlight and ultra-violet light transform this *2*-pentene into an isomeric form of slightly different physical properties. The transformed *2*-pentene adds HBr to form 15% of *3*-bromopentane and 85% of *2*-bromopentane. Addition of Br_2 yields *2,3*-dibromopentane.
3. Pentene-*2* prepared from *2*-bromopentane and carefully purified has a slightly lower refractive index, boiling point, and density, than has *2*-pentene prepared from *3*-bromopentane.*
4. This *2*-pentene (without solvents) adds HBr to form 93–95% *2*-bromopentane. In a polar solvent such as glacial acetic acid it adds HBr to form 85% of *2*-bromopentane. Addition of Br_2 yields *2,3*-dibromopentane.
5. The action of ultra-violet light on the *2*-pentene obtained from *3*-bromopentane tends to alter its properties in the direction of those of the electro-isomeric *2*-pentene obtained from *2*-bromopentane, while the latter electro-isomer remains practically unchanged by ultra-violet light.
6. The ultra-violet absorption spectra of the *2*-pentene prepared from *2*-bromopentane and of the *2*-pentene from *3*-bromopentane show marked differences, particularly in the region of the shallow absorption band in the near ultra-violet. The absorption curves of the two electro-isomers are so characteristic that they have given an excellent method of identifying these isomers as well as of differentiating them from *1*-pentene and the polymeric forms of *2*-pentene which may be present as impurities.
7. The effect of a polar solvent, glacial acetic acid, on the absorption spectra of the two electro-isomeric pentenes shows that in each case the acetic acid shifts the absorption curve slightly toward that of the other isomer. In a non-polar solvent, hexane, each curve is almost identical with that of the pure liquid. These results are in accord with the addition reactions of the isomeric pentenes in the two solvents.
8. Absorption spectra measurements of the *2*-pentene from *3*-bromopentane before and after prolonged exposure to diffused light or before and after exposure to the ultra-violet light of the mercury arc for eight or nine

* This work has recently been repeated and confirmed by Clark and Hallonquist (*171*). These authors also report that the two electro-isomers differ appreciably in freezing point.

hours show a decided shift in the absorption corresponding to a transformation into the isomeric *2*-pentene. The *2*-pentene prepared from *3*-bromopentane is quite stable under illumination and shows only a very slight shift of absorption in the opposite direction.

To summarize, it is to be expected that whenever the substitutents at opposite sides of the double bond are nearly equal in electronegativity, a mixed product will be formed upon the addition of a halogen acid. Although it is *ordinarily* to be expected that the major portion of the product will consist of that compound which results from addition of the halogen ion to the carbon atom already carrying the more electronegative substituent (or substituents), it is possible, in cases where the polarity of the double bond is slight, to vary the proportions of the addition compounds at will within very wide limits by suitable pre-treatment of the olefine or by suitably varying the conditions of the addition reaction.

It will also be found that some olefines containing double bonds of sufficient polarity to preclude the existence of the unstable electro-isomer under ordinary conditions will yield anomalous addition products with halogen acids at higher temperatures. This circumstance is attributable to the fact that as the temperature is raised the reaction ceases to be one of simple addition and is complicated by simultaneous dissociation and re-addition reactions (as well as by various other side reactions). Although such anomalous products are sometimes formed at temperatures below those which vapor pressure measurements indicate to be the dissociation temperatures of the pure addition compounds, Menschutkin and Konowalow (*133*), (*134*), (*135*) have demonstrated that the presence of small amounts of other substances will lower the dissociation temperatures of alkyl bromides to a surprising extent.

Furthermore, it is well to note that reactions in which addition is incomplete or in which only a portion of the addition product is identified are often poor guides in the formulation of addition rules. In compiling Table III, therefore, we have avoided including incomplete additions in so far as the information given in the literature permitted us to do so and have listed very few high-temperature additions, most of which are specifically indicated. For obvious reasons, catalytic additions are also omitted.

Consideration of Some Criticisms of the Authors' Views

At this point it appears desirable to introduce a brief discussion of certain criticisms of our views which have appeared in the literature. We realize fully that engagement in polemics generally constitutes an unprofitable use of time and energy which might be spent to better purpose in further creative work. The true value of a theory or hypothesis must be determined by its utility and is in no way related to the debating prowess of its proponents. Therefore, it will not be our custom to rush into

print with refutations of arguments purporting to expose fallacies in our system of notation or in our reasoning. We have found the views here set forth useful in correlating and unifying a large body of hitherto empirical facts. We present them in the hope and belief that they may prove equally useful to others, and we are entirely willing to let this constitute the test of their survival and adoption.

In the present instance we are moved to make an exception to our general policy by the following considerations. The ideas and the experimental evidence which constitute the framework of the general theory exposed in the first and in the present articles of this series have appeared previously in the technical literature. We have not, however, heretofore attempted to present them in detail and in thoroughly organized form for the especial consideration of teachers and students of organic chemistry. We feel that it would be regrettable if any were prevented from examining this exposition and forming an independent opinion upon it by reason of a mistaken impression that it has already been made the object of a number of well-reasoned and unanswerable attacks. With this apologia let us to our cudgels and dispose of an unpleasant task as quickly as may be.

It may be well to emphasize at the outset a fact which has sometimes been specifically stated and which has always been implied in previous publications by one or both of us. The *system of notation* employed by us has been adopted as the simplest and most convenient for the correlation of phenomena involving *chemical reactivity*. No attempt has been made to elaborate it to the point where it takes account of all conceivable physical data. We are content if it remains *consistent with such physical data as may properly be employed to test it.* If it were shown to contradict arbitrarily some unequivocal physical fact the desirability of revision would be indicated, although the *chemical utility* of the notation might be no whit diminished.

In this connection we cannot refrain from urgently recommending that all chemists who have not already done so give serious and thoughtful consideration to the presidential address of Dr. Langmuir delivered at the seventy-eighth meeting of the American Chemical Society (*137*). Particularly pertinent to our present theme is the paragraph which follows:

> Skepticism in regard to an absolute meaning of words, concepts, models or mathematical theories should not prevent us from using all these abstractions in describing natural phenomena. The progress of physical chemistry was probably set back many years by the failure of the chemists to take full advantage of the atomic theory in describing the phenomena that they observed. The rejection of the atomic theory for this purpose was, I believe, based primarily upon a mistaken attempt to describe nature in some absolute manner. That is, it was thought that such concepts as energy, entropy, temperature, chemical potential, etc., represented something far more nearly absolute in character than the concept of atoms and

molecules, so that nature should preferably be described in terms of the former rather than the latter. We must now recognize, however, that all of these concepts are human inventions and have no absolute independent existence in nature. Our choice, therefore, cannot lie between fact and hypothesis, but only between two concepts (or between two models) which enable us to give a better or worse description of natural phenomena. By better or worse we mean, approximately, simpler or more complicated, more or less convenient, more or less general. If we compare Ostwald's attempts to teach chemistry without the use of the atomic theory with a good modern course based upon the atomic theory, we get an understanding of what should be meant by better or worse.

ELECTROSTATIC PROBABILITY

To turn our attention to specific criticisms, however, our method of assigning relative electronegativities to substituted methyl radicals has been attacked by Smyth (*138*) and by Wooster and Mitchell (*139*) on the ground that it is "*electrostatically unsound.*" To quote the former author:

The more electronegative radicals draw their binding electron pairs farther away from the carbon to which they are attached, thus increasing the effective nuclear charge of this carbon. The increased charge should tend to shift any other adjacent electrons toward this carbon and thus increase very slightly the effective nuclear charge of the carbon away from which they have shifted.* . . .The postulate of Kharasch and Darkis requires that the electrons be forced away from the carbon with the higher effective nuclear charge toward that with the lower charge. However effective such a postulate may be in explaining chemical behavior, it appears electrostatically unsound.

Our adherence to the view described does not arise, as Smyth implies and as Wooster and Mitchell directly suggest, out of any oversight of the objection raised. Rather, considering the objection, we perceive that it is begotten by *a priori* reasoning out of a rather literal acceptance of a static atomic model.

The experimental evidence demonstrates (conclusively, we believe) that the benzyl radical is less electronegative than the methyl radical. All of the chemical phenomena with which we are acquainted point to the conclusion that as successive hydrogen atoms of the methyl group are replaced by phenyl (or other highly electronegative) radicals the substituted methyl radical as a whole becomes less electronegative. In terms of our notation we express this fact by saying that it holds its remaining electron pair in progressively outer energy levels (see Figure 2, p. 1712).

It is not altogether clear whether Smyth and Wooster and Mitchell intend to question the validity of the experimental data of which we have

* This point of view has been attributed to Lewis and has in fact been employed by him tentatively. That he recognized the possible influence of other factors than those postulated by classical electrostatics is, however, amply demonstrated by the quotation which we have inserted on page 1714.

given a generalized description in this fashion, or whether they merely object to the system of notation adopted by us to describe the experimental facts. We feel that if their objection is to be valid they should be more explicit on this point.

We ourselves believe that these authors are inclined to lay too much stress on the simple classical laws of electrostatic attraction and to lose sight of the fact that molecules are extremely complicated dynamic systems. It is not irrelevant to remind the reader that symmetry considerations, among others at present little understood, are none the less highly significant in determining the stabilities of electron-proton systems. It may be that there are strong influences which we cannot now analyze in detail but which nevertheless operate in favor of a symmetrical electronic distribution.

We can only reiterate our statement of the necessity of exercising extreme caution in attempting to arrive at conclusions concerning probable electronic behavior by *a priori* processes, and cite again the chlorophenyl and methoxyphenyl radicals already discussed on pp. 1721–2 as giving point to this warning.

ELECTRIC MOMENTS

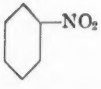
Smyth (*138*), (*140*) has also emphasized the fact that certain molecules, notably the isomers of heptane, do not possess the electric moments which he believes to be predictable upon the basis of our table of relative electronegativities of organic radicals. Here again it is not entirely clear whether Smyth and we are discussing precisely the same thing. In evaluating Smyth's criticisms, however, it is necessary to keep certain facts in mind.

1. The electric moment of a molecule bears no as yet demonstrable relation to its reactivity.* Hence it follows that the measurements which permit the calculation of electric moments are incapable of detecting the "physical realities" which underlie reactive characteristics. This being true, it is obvious that no system of notation which does not contain features that electric moment measurements are incapable of detecting can possibly account for chemical reactivity. Therefore, to say that electric moment data furnish no support for the views implicit in a notation of this sort is merely to admit that the system of notation may be successful in accounting for chemical reactivity.

Thus it is well known that the *meta* hydrogen of nitrobenzene is less reactive than a benzene hydrogen; the *para* hydrogen of chlorobenzene is also less reactive than a benzene hydrogen, while the *para* hydrogen of phenol is considerably more so and that of toluene is somewhat more so

* This conclusion may be drawn from one of the papers by Smyth already cited (*138*); it is specifically stated in a paper which has appeared since the present article was written (*138.5*).

(*141*). Listing these compounds in descending order of reactivity of the most readily replaceable hydrogen and comparing the electric moments, it is obvious that there is no correlation.

Molecule	$\mu \times 10^{-18}$	
	1.63	(*142*)
	1.7	(*143*)
	1.73	(*144*)
	0.4	(*143*), (*144*), (*145*)
	ca. 0	(*142*), (*145*)
	1.52	(*142*), (*147*)
	1.55	(*142*), (*143*), (*145*)
	1.61	(*144*)
	3.8	(*143*)
	3.89	(*142*)
	3.90	(*146*)

Furthermore, methane and carbon tetrachloride are both molecules of zero moment, yet every organic chemist realizes that the vast differences in their chemical behavior must arise out of differences in the disposition of their bonding electrons. Additional examples would be superfluous.

2. It is evident that Smyth misunderstands our postulates and their implications and hence has failed to realize that his method is inherently incapable of serving as a test of our theory. Striking evidence of this misunderstanding is found in his statement (*138*) that Smyth and Zahn have found ethylene to be non-polar, "while the postulates of Kharasch and Darkis would lead us to expect marked polarity." It is difficult to see how such an impression could have been gained. Nothing in the previous publications of one or both of the present authors could possibly be construed as indicating or implying that ethylene itself is anything other than perfectly symmetrical electronically. Only the unsymmetrically substituted derivatives of ethylene are assumed to possess any polarity.

Moreover, the radicals as listed in our table must be regarded as somewhat in the nature of hypothetical ions. When they are combined with other radicals or with atoms to form molecules, an electronic readjustment takes place throughout the entire resultant molecule. When this readjustment has taken place the resultant of the electrostatic charges through-

out the molecule as a whole may or may not be such as to give rise to an electric moment.

For instance, we believe that the methyl radical differs in electronegativity from the hydrogen atom. Yet we do not predict that, when a hydrogen atom and a methyl radical are combined, a molecule with an electric moment will be formed. We further believe that the phenyl radical differs in electronegativity from the hydrogen atom, yet we do not predict on that basis that benzene should show an electric moment.

3. While it may be possible to select an atom or a bond in a molecule and to state that the molecule is unsymmetrical with respect to that atom or bond it does not necessarily follow that the molecule will take cognizance of that arbitrary selection when submitted to the measurements from which electric moments, if any, can be calculated. That is, it does not follow from the fact that one or more bonds in a molecule are unsymmetrical, or from the fact that the molecule is unsymmetrical when a given atom is taken as a point of reference, that the molecule as a whole will display an electric moment.

For instance, it cannot be doubted that the individual chlorine-to-carbon bonds in CCl_4 are unsymmetrical, yet the molecule as a whole has no moment. As a further example, it is possible to consider normal hexane as ethylpropylmethane, methylbutylmethane, amylmethane, or even as hexyl hydride, but it still remains normal hexane and it shows no electric moment.

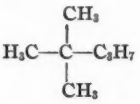
The methyl radical differs in electronegativity from the phenyl radical and toluene does have an electric moment but that moment is not even an indirect measure of the difference in electronegativity of the two radicals. Chlorine differs in electronegativity from the phenyl radical and chlorobenzene has an electric moment but that moment is in no sense a measure of the difference in electronegativity of these two individual constituents. The moments in both cases are the resultants of complicated electronic shifts which have taken place throughout the entire molecule.

4. Most organic molecules are not rigid, as Smyth himself has emphasized in an earlier paper (*148*). Yet the electric moment of a molecule is determined not only by the resultant of such polarities as may exist among its constituent atoms and groups but by the geometrical configuration of the molecule as a whole. It is probable, as Smyth contends, that the non-rigidity of a molecule permits geometrical "distortions" which tend to minimize the electric moment, and which may entirely neutralize the effects of very small polarities.

5. Finally, the electric moment is inadequate, even under very favorable circumstances, to detect *small* differences in electronegativity which are not only definitely known to exist but which can be measured quantitatively.

For instance, it is definitely known that chlorine is more electronegative than bromine, and electrode potentials are capable of giving us a quantitative indication of the difference in electronegativity. Yet Smyth (*138*) cites *trans*-CHCl=CHBr as a molecule having no electric moment.

With these considerations in mind a detailed reply to Smyth's remarks on the isomeric heptanes scarcely seems necessary. It is entirely possible to consider *2,2*-dimethylpentane, for example, as propyltrimethylmethane and to note that the molecule is unsymmetrical with respect to the methane carbon atom.



We have no reason to think, however, that this molecule does regard itself as a quadruply substituted methane and behave accordingly when subjected to dielectric constant measurements. We *have* reason to believe that it is non-rigid and to suspect that it might so adjust its geometrical configuration as to neutralize entirely any slight polarity which might conceivably exist within it.

ACTION OF POTASSIUM ON PHENYL-SUBSTITUTED METHANES

Wooster and Mitchell (*139*) point to the action of potassium metal on phenyl-substituted methanes in liquid ammonia as indicating that "the ionization of methane (as hydrogen methide) appears to be progressively increased by the substitution of phenyl groups," which is in accordance with Lewis' idea, but is the reverse of that which would be expected on the basis of the table of electronegativities presented by Kharasch and Marker (*35*).

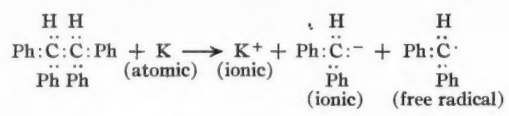
The entire line of argument advanced by Wooster and Mitchell rests upon the assumption that: "The fact that many colored organo-alkali compounds conduct the electric current in ether and in liquid ammonia solution and behave in other ways as salts, implies that the corresponding hydrides should exhibit an acidic character, albeit an exceedingly weak one." If the term "acidic character" is to be interpreted in its proper sense as indicating an ability to ionize, with the proton as the positive ion, the implication assumed is obviously extremely tenuous. On this basis it should follow that ethane, for instance, is an acid in ether solution, since zinc diethyl dissolved in ether has a specific conductivity of about 10^{-4} (*149*). The unfortunate consequences of employing formal and uncritical definitions of classes of compounds are here strikingly evident.

It is to be noted that Wooster and Mitchell did not investigate the supposed acidic character of the phenyl-substituted methanes by any of the conventional methods employed in the evaluation of acid properties, for

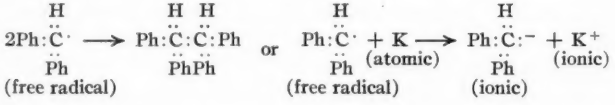
the good and sufficient reason that "triphenylmethane does not conduct appreciably in liquid ammonia" (*150*). (Triphenylmethane is, according to Wooster and Mitchell, the most acidic of the phenylated methanes.) Nevertheless these authors assume that the hydrocarbon actually ionizes into hydrogen and hydrocarbon ions and that only the former reacts with the alkali metal. Actually, they employed one of the most powerful reducing agents available, and based their conclusions concerning acidity upon the occurrence or non-occurrence of a reaction which might be most plausibly described as a molecular reduction.

It is often a dangerous and a profitless task to speculate upon the nature of a reaction mechanism; hence we shall present our view merely as a possible and (to us) more plausible alternative to that of Wooster and Mitchell. It seems to us, then, that a reaction of this type must take place through the injection of an electron into an outer energy level of one of the atoms of the hydrocarbon molecule with the resultant attachment of the metal atom and the detachment of a hydrogen atom. Of the atoms that are eligible to receive an electron (if we may employ that phrase) the atom which has the larger field of force will actually be the recipient. Thus in diphenylmethane, for example, the two methane hydrogen atoms and the methane carbon atom may all be considered as eligible to receive an electron, but the carbon atom has the largest field of force and may actually be the recipient of it. Benzyl chloride has four atoms which may be considered as eligible to receive an electron in a reaction of this type, namely the methane carbon atom, the methane hydrogen atoms, and the chlorine atom. The latter has the largest field of force, acquires the proffered electron and separates from the molecule as a chloride ion, combining with the resultant metal ion to form a salt. The hydrocarbon radical is left to combine with another of the same kind, forming dibenzyl. (*151*), (*152*), (*153*). In the case of diphenylmethane, however, the carbon atom receives the electron, as we have already said, and stability is regained by the elimination of a hydrogen atom which combines with another hydrogen atom to form molecular hydrogen.

It is pertinent to our subject that this property which we have designated as "eligibility to receive an electron" is common to carbon atoms whose valence electrons have been drawn into outer energy levels through sharing with comparatively electronegative organic radicals. Hydrogen is not always the group eliminated in the consequent splitting of the molecule. When a group less electronegative than hydrogen is present that group may be cast off. For example, *sym*-tetraphenylethane reacts with sodium-potassium alloy in dry benzene or ether solution to form sodium diphenylmethyl (*172*), (*173*). Apparently it reacts similarly with potassium metal in liquid ammonia (*139*). In accordance with our views we would write the first stage of the reaction as follows:



Obviously in this case it is immaterial whether we write for the second stage:



No doubt both reactions take place.

Analogous reactions occur when $(C_6H_5)_2CHCH_2C_6H_5$ and $(C_6H_5)_3C\text{-}CH_2C_6H_5$ are treated with alkali metal (*172*), although not all of the products have been identified, so that it is impossible to say definitely just what the second stage in these reactions is.

Granted that the mechanism of these reactions is as we have outlined it, it is only reasonable to suppose that such a reaction will take place only when the carbon atom concerned holds the electrons it already has rather loosely, and that it will take place more readily the more loosely the original electrons are held. On the basis of our theory, therefore, the experimental results cited by Wooster and Mitchell are entirely in accord with reasonable expectation.

It is not utterly irrelevant to the point under discussion to note the well-known fact that in the group including carbon, silicon, and germanium, the metallic character of the elements increases with increasing atomic number (in quadrivalent compounds). This is to say, in the terminology of the present authors, that the electronegativity decreases. Under any system of interpretation this requires that the acidic character of the hydrides decrease in the order: methane > silicane > germane.

Upon the basis of the criterion of acidity adopted by Wooster and Mitchell, however, one would be forced to place these hydrides in the reverse order, for germane is the only one which reacts with alkali metal (*154*). In the light of our own interpretation no contradiction or anomaly occurs.

Hence it is seen that, contrary to the statement of Wooster and Mitchell, our theory is entirely in accord with the experimental facts. It is only upon the basis of an assumption as to the mechanism of the reactions in question which our theory would automatically exclude that they are made to appear otherwise.

NON-EXISTENCE OF CERTAIN FREE RADICALS

Wooster and Mitchell (*139*) also call attention to the fact that, whereas chlorine is assumed to be more electronegative than the phenyl radical, our theory of free-radical formation would predict dissociation of such compounds as symmetrical dichlorotetraphenylethane, dichlorotetradiphenylethane, and hexachloroethane, into free radicals. None of these, they say, "appear to be dissociated into free radicals." These facts were neither unknown to, nor ignored by us, but they are not considered as necessarily constituting a "marked discrepancy."

In the first place, our hypothesis states that the dissociation of a hexasubstituted ethane will be promoted by any substituent above the phenyl radical in our table of electronegativity. The well-established facts, we believe, are definitely in accord with this hypothesis. The positions of the halogens with respect to the organic radicals studied has not been determined. It is premature, therefore, to draw any conclusions with respect to the relative position in our table of a carbon atom loaded with halogens. The necessity for the exercise of caution in *a priori* reasoning, which we have stressed throughout this paper, is again emphasized.

Aside from this aspect of the matter, we believe that Wooster and Mitchell lay undue stress upon the explicit aspects of structural formulas, and forget that implicitly there are many ways in which a molecule may relieve internal stress, and what appears to us most pertinent and important regarding the cases in question is that the formation of free radicals is only one of the possibilities. Thus the great lability of the halogen atoms in such compounds as dichlorotetraphenylethane provides a second possible mechanism by which the dissociation of the molecule can take place. In fact these compounds do eliminate chlorine or hydrogen chloride or both when subjected to conditions under which free-radical formation usually takes place* (*155*), (*174*), (*175*).

Summary

The classical hypotheses concerning the nature of the ethylene bond leave much to be desired in that they offer no explanation for the obvious differences in behavior exhibited by individual double bonds in divers ethylene derivatives. Empirical rules have had considerable utility but they are not universally applicable, and the truly scientific fundamentals underlying them are not obvious.

The Lewis concept of the electronic nature of the valence bond offers a more fruitful basis for the formulation of hypotheses. Several contemporary extensions of the Lewis concept are here shown to be inadequate, for they lead to predictions which force one to classify much of the experimental evidence available as anomalous.

* Also pertinent to this subject is the discussion on page 1721.

The notation advanced by one of us (Kh.) and described in the present paper is shown to be general in that it is applicable to a wide range of compounds and phenomena and that it is in accord with such physical data as may properly be employed to test it. It is unique in that its implications and predictions are in agreement with the available experimental data on the directed addition of halogen acids to ethylene derivatives. Furthermore, it accounts satisfactorily for the relative stabilities of addition products.

The probable existence of electro-isomers implicit in the authors' notation has now been supported by experimental evidence, which is here summarized.

Certain criticisms of the notation described have been shown to be irrelevant.

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(*3*) BERTHELOT, *Ann. chim. Phys.* [7], **20,** 27–42 (1900).

(*4*) See, for example, (*a*) BEASLEY, INGOLD, and THORPE, *J. Chem. Soc.*, **107,** 1080–1106 (1915); (*b*) INGOLD and THORPE, *ibid.*, **115,** 320–83 (1919); and (*c*) INGOLD, *ibid.*, **119,** 305–29 (1921). For a brief general discussion of Baeyer's hypothesis see (*d*) COHEN, "Organic Chemistry," Edwin Arnold & Co., London, 5th edition, **1928,** Part I, pp. 199–209, or (*e*) HENRICH, "Theories of Organic Chemistry" (translated by Johnson and Hahn), John Wiley & Sons, Inc., New York City, **1922,** pp. 18*ff*.

(*5*) For an outline of THIELE's hypothesis of free valencies see reference (*4e*), pp. 35*ff*.

(*6*) HINRICHSEN, *Ann.*, **336,** 223 (1904).

(*7*) MARKOWNIKOFF, *ibid.*, **153,** 256–7 (1870).

(*8*) MARKOWNIKOFF, *Compt. rend.*, **81,** 670 (1875).

(*9*) WAGNER and A. SAYTZEFF, *Ann.*, **179,** 324–5 (1875).

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Mercury Vapor to Replace Steam in Large Power Generator. A new and larger turbine electric generator using mercury vapor instead of steam and producing power more cheaply than existing steam plants is being constructed at Schenectady, New York.

This 20,000-kilowatt turbine will have twice the output of the mercury vapor engine and generator which has already proved its superior efficiency over steam turbines during a period of a year at Hartford, Connecticut. The new plant will be the first outdoor steam plant and will be even more efficient than the Hartford station.

The mercury is boiled over a fire and the vapor is played on the blades of a turbine wheel as in a steam generator but at a much higher temperature. The advantage of the quicksilver over water is due in the first place to its higher boiling temperature. This allows the engineer to use his mercury at as high as 950 degrees Fahrenheit without producing uncomfortably high pressures in the boiler.

One of the most fundamental principles of physical science, the second law of thermodynamics, has been used in this invention by W. L. R. Emmet, who devised the first mercury turbine. According to this law the greater the temperature range of a heat engine the greater the efficiency. The difference between the temperature of the vapor coming from the boiler and the temperature of the condenser determines the temperature range of the engine.

The hot mercury vapor in the exhaust of the turbine instead of being condensed by water is used to raise steam for other steam turbines. This effects a further economy in fuel used per unit of power produced.

The high-pressure steam thus produced is conveyed to the steam turbines and other units through long underground pipes. A 110,000-volt transmission system is supplied by the electric generator coupled with the mercury turbine.

A quarter of a million pounds of mercury are used in this installation though on account of the great density of the liquid this is thirteen times less bulky than the same weight of water. The world is squandering its resources of this metal in Italy, Spain, and the United States very lavishly just now. The advantages of the new turbines are so great, however, that some of the supply will certainly be diverted to constructing them to replace existing steam plants.

Fortunately none of the mercury is lost in the operation of the boiler and turbine. All joints are made vacuum tight. The vapor is a very insidious poison even in small amounts if breathed over a period of time.—*Science Service*

THE STORY OF NICKEL. PART I. HOW "OLD NICK'S" GNOMES WERE OUTWITTED

WILLIAM H. BALDWIN,* INTERNATIONAL NICKEL COMPANY, INC., NEW YORK CITY

The story of nickel is that of an alloy. Known first in the meteoric iron from which the mythological warriors of Persia fashioned their "Heaven-sent" blades and then introduced into commerce in the ancient Chinese alloy, paktong, nickel began its Occidental history in the middle of the eighteenth century when German copper and silver miners stumbled over it in working new lodes of what seemed to be most promising ores.

When one considers that the name nickel is derived from "Old Nick" who was charged by these superstitious Christians with having bewitched the ores with this unknown element, it becomes obvious that the discovery of nickel was not a welcome experience. Gradually, however, the scientists of the day learned how it could be isolated and what its valuable properties are.

For a time nickel mines were worked in America, Europe, and the Antipodes. Then the great deposits in Sudbury, Ontario, were discovered. Soon production outstripped the demand for its known uses. Then French experiments with nickel-steel alloys set new standards for armor plate and munitions of war. The demand for nickel rose rapidly until, during the World War, every available source of nickel was worked to the utmost.

Largely through the efforts of a small group of Americans, the Sudbury deposits were, first, developed in the face of great difficulties and then kept intact in the face of tempting offers from German interests.

. . . . . .

It is a far cry from the "Heaven-sent" blade of the mythological swordsman of Persia or China to the nickel-steel rotor hub which is the very heart of the modern autogiro, but the two are inextricably linked in the story of nickel. Then as now life hung on the dependability of an alloy. Where the fabled warrior had a simple faith in his blade forged from meteoric iron with its high nickel content, the flier today goes up with assurance that science knows exactly the content and the strength of the nickel-steel which has been carefully alloyed for his protection.

In the transition from fable to fact nickel picked up its name at a time when men thought it was sent by the Devil and not by Heaven. In the early part of the eighteenth century fresh lodes of ore were laid open in Saxony where from times immemorial silver and copper mines had been worked. This new ore was so glittering and full of promise as to cause the greatest excitement, but after innumerable trials and endless labor all that could be obtained from the ore was a worthless metal. In disgust the superstitious miners named the ore *kupfer-nickel* (copper-nickel) after "Old Nick" and his mischievous gnomes who were charged with plaguing the miners and bewitching the ore.

* Public Relations Counsel to The International Nickel Company, Inc. The author reserves all rights in this article.

What these German miners gave up in disgust the scientists explored with avidity. Gradually the story of nickel began to take shape and direction; but the name coined by the ignorant laborers stuck. Nickel it always has been in every language of Europe.

By 1751 Cronstedt had isolated a new element which he named nickel, but it was not until a quarter-century later that this discovery was confirmed by Bergman. Another thirty years elapsed before Richter produced the first pure nickel and gave a remarkably accurate description of its properties. In the meantime von Engestrom was studying the famous *paktong*, or "white copper," which was first brought out of China in the caravans to Bactria two centuries before the Christian era. These ancient experimenters with metallurgy had found a copper-nickel ore in Yunnan Province and had learned that the addition of zinc created an alloy which was workable, useful, and attractive in appearance. Before our Revolutionary War the copper-nickel ores of Litchfield County, Connecticut, were being shipped out to the Far East to supplement the Yunnan ores in the growing paktong industry. This alloy then took a sea voyage to Europe where it enjoyed a growing popularity as a substitute for silver, and where it thus came under the analytical eyes of von Engestrom.

In those days there was little or no interchange of scientific information between the Orient and the Occident, and the Swedish scientist, therefore, had to find out by patient research that paktong contained copper, nickel, and zinc. There followed fifty years of struggle with "Old Nick's ores" to learn what any Chinese metallurgist could have told the West: how to make a satisfactory imitation of paktong. But once the secret of zinc's function in the process was discovered, there came a flood of white metal products under such trade names as *argentan* and *metal blanc*, the generic name being German silver and remaining such until recent years when nickel-silver has become the accepted name for these alloys.

It was the development of electroplating as the result of Faraday's researches in electromagnetism that stimulated the use of nickel with twofold effect, the more important being the introduction of silver plating on a German-silver base, and the other being nickel-plating itself. This development was well under way by the middle of the nineteenth century, when a further impetus was given to nickel consumption by a revolutionary change in policy toward token-money coinage. A Belgian commission on currency reform effectually assailed in 1859 the prevailing theory that the intrinsic value of token money must approximate its nominal value, and the following year Belgium adopted as standard a composition of 75% copper and 25% nickel because of the economy, workability, and appearance of this alloy. The United States followed suit in 1865, Germany in 1873, and Switzerland in 1879. In the meantime Joseph Wharton, of Philadelphia, was working with malleable pure nickel; and the showing of his

An Eighteenth Century German's Conception of Mining Operations
(From Bruckmann's "Magnalia Dei in Locis Subterraneis," 1730.)

products at the Vienna Exposition in 1873, the Philadelphia Exposition of 1876, and the Paris Exposition of 1878 created widespread interest in this product. The Swiss were the first to adapt it to coinage, and in 1881 they issued the first pure nickel money. Since then some twenty-four countries have stamped three billion pure nickel coins for use in their currencies.

At the same time another field of usefulness was being opened up by Fleitmann who obtained malleability by adding small amounts of magnesium to the melt. He succeeded in rolling nickel so treated into sheets, and then in rolling these sheets upon both iron and steel, much as silver was rolled on copper in the manufacture of Sheffield plate. Thus he became the pioneer in the development of what is known today as nickel-clad steel.

* * * * * *

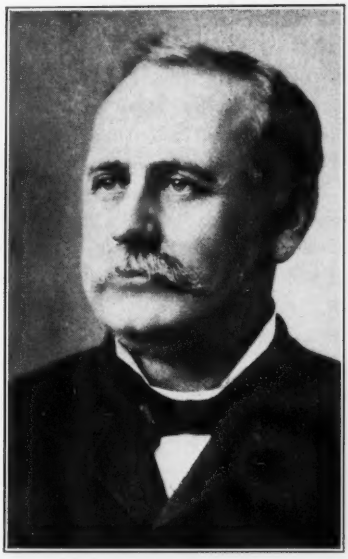
Naturally this expanding consumption necessitated increased production of the raw material. For a time the whole world was combed for supplies, and ores containing as little as one per cent of nickel were profitably worked. Practically every country contributed its mite, but the pyrrhotite-chalcopyrite deposits of Norway emerged as the greatest source, reaching their highest production in the years 1870–77.

Then mining in New Caledonia got under way, and a decade later this competition had brought all other nickel mining, save that in Norway, to a standstill. Until near the close of the century that little island in the South Seas was the principal source of nickel for an enormously increasing demand.

For the next and, apparently, the last time the pendulum then swung again, and less than 1000 square miles in the Sudbury district of Ontario, Canada, became the lodestone of the nickel industry. Discovered in 1856, it was not until the Canadian Pacific Railway was being pushed westward from Sudbury, a generation later, that this deposit really came to notice. Even so, the outcrop of ore, which a railway cut laid bare, was first valued for its rich copper content. And here history repeated itself; for those who tried to smelt the copper found it as thoroughly bewitched as had the German miners a century before.

Discovery of the Sudbury deposits was the prelude to a revolution in the nickel industry. At the time the world's production was some 1000 tons annually and the price had reached a peak of $2.50 a pound. Extraction of the metal was by the wet method in which the copper-nickel product from the smelters was dissolved in some such acid as muriatic and then the copper and the nickel were precipitated in turn. The process was costly and did not lend itself to quantity production. At the same time the potential production of these rich deposits was so great, and the uses of nickel were so restricted, that the price tobogganed until it reached sixteen cents a pound.

Samuel J. Ritchie, a typical American promoter from Akron, Ohio, was an early figure in this new phase of nickel's story. He had interested a group of Cleveland capitalists in the construction of the Central Ontario Railway. That road was in a bad way at the time and its only salvation was to find some freight to haul. Ritchie heard of the copper discoveries at Sudbury, obtained options on several of the best mines and induced his backers to organize the Canadian Copper Company and buy the mines. That was in 1885. The next step was to contract with copper refiners to take over the ore produced.



SAMUEL J. RITCHIE

The American promoter who went into Canada after copper and came out with nickel.

Here Colonel R. M. Thompson and the Orford Copper Company, of Constable Hook, New Jersey, enter the picture. Thompson was an Annapolis graduate with an honorary military title conferred by the State of New Jersey. After a few years at sea he had resigned from the Navy to study law at Harvard, and then had started to practice in Boston. Soon he had forgotten law and was on the road to becoming one of the great industrial metallurgists of America. Likewise, his company had undergone equally rapid transmutations. It had started as the Orford Nickel Company to exploit a nickel mine near the village of Orford, Quebec. The ore proved refractory and the company became interested in leasing a copper sulfide mine at Capleton. Thompson, then a lawyer, was retained to handle the negotiations. Upon going to England to treat with the owners of the mine, he decided that it would be more profitable to purchase instead of lease. This he proceeded to do, much to the surprise of the directors of the Orford Nickel Company, who, however, approved the purchase and reorganized as the Orford Copper & Nickel Company with Thompson as general manager. In due course it was decided to erect a smelter near New York. Thompson was sent there, bought four acres of sunken meadow, prevailed on New York officials to dump their ashes and rubbish there instead of at sea, and thus developed at small cost a tide-water site for his smelter. Before long copper ores from the western mines appeared at the seaboard for refining, and soon this business had crowded out the

working of the ore from Capleton. With the assistance of a loan from W. A. Clark, Thompson bought out his Boston friends and reorganized as the Orford Copper Company. Thus nickel was completely eliminated from the corporate title, and almost immediately the company was launched on a development that was to make it one of the world's greatest producers of nickel.

What happened was that Thompson had contracted to buy 100,000 tons of ore from Ritchie. The first shipment was received in the autumn of 1886, and the smelt produced a pale metal that no copper fabricator would accept. Thompson then had an exhaustive analysis of the ore made, and he was advised that it contained $2^1/_2$ per cent nickel. Ritchie, told the trouble, was greatly depressed until he learned that nickel was then worth $1 a pound. Realizing that his ores would produce many times the world's annual consumption of nickel, Ritchie cast about for some new uses of the metal. With poetic justice the nickel-iron meteorites which had provided the Heaven-sent blades of the ancient warriors furnished the basis for his answer. Some ten years earlier he had visited the Smithsonian Institute with one John Gamgee, an Englishman who had interested our Government in the construction of a refrigerator ship for the treatment of yellow fever patients in the Gulf ports. Gamgee had found that cast iron tanks would not hold the ammonia gas he required for refrigeration, nor had he been able to discover any alloy that was an acceptable substitute. The attention of these visitors had been attracted by the brightly polished surface of a meteorite. They had discussed the possibility of producing synthetically a similar alloy. Gamgee had obtained some nickel from Joseph Wharton and, after considerable experimentation, had developed a superior alloy containing 8 per cent nickel.

All this Ritchie now remembered, and he thereupon made a grand gesture. He wrote Krupp—already a famous gunmaker—and suggested the possibilities of the Gamgee alloy in the manufacture of ordnance. The answer was a more or less amused rejection of the idea on the ground that there was not sufficient nickel in the world to warrant experimentation in this field. To a man as conscious as Ritchie was of the world's surplus of nickel stocks, such an answer must have been exasperating. But he had made his gesture.

However, Krupp—thanks to France—had smiled too soon for two good reasons. First, the French had developed chrome-steel projectiles that raised havoc with the wrought iron and compound armor-plate then standard in the navies. Second, a Frenchman was attracting attention by his production of ferro-nickel and nickel-steel. A British armor-plate manufacturer investigated, and the result was that in 1889 James Riley presented his now famous paper on "Alloys of Nickel and Steel." Our Navy became interested, and, after its own investigation, purchased plain steel

plates from British and French manufacturers and a nickel-steel plate from Le Creusot works of Schneider in France. At the trial of these plates in 1891 the nickel-steel proved decisively superior, world-wide interest resulted, and Congress made a large appropriation for the purchase of nickel to be used in making armor plate for our Navy.

In the next chapter in the history of nickel Colonel Thompson emerges as an heroic figure. His training at Annapolis had given him an understanding of naval affairs, a deep loyalty to our Navy, and a wide circle of friends among the officers and technicians in the Department. Although Wharton was the one great American producer of nickel—his output was exactly 180 tons a year—it was to Thompson and his Orford Copper Company that the Navy Department turned. He protested, but the department replied that it was in no great hurry and would give him a year in which to begin delivery. On or about the 365th day of that year the Orford Copper Company shipped to the Navy a quantity of red ferronickel oxide which was pretty terrible, according to modern metallurgical standards, but which was acceptable to the steel makers.

ROBERT M. THOMPSON

Annapolis graduate with a military title, whose Orford Copper Company became the turning point in the story of nickel.

But Thompson fully realized that he was licked unless he could get a more satisfactory process than the wet method. One day he was in the refinery when some hundred pots of matte had been dumped on the floor. He tapped one of these cones with a sledge hammer and noticed an unusal fracture. He then tapped cone after cone until he had gone through the whole lot. A score of them had fractured in the same way—the bottom third of the cone had broken away as a bright sulfide from the top two-thirds which showed dark and flaky. Samples were taken and proved that an almost pure nickel sulfide had settled in the bottom third while the top section contained copper, iron, some nickel, and a large amount of sodium. Thereupon Thompson began to function. Upon inquiry he learned that various residues from the chemical house had been part of the charge that had produced this unusual matte. He detailed a man to melt normal matte in crucibles, each with one of the chemicals used in the plant. One heating after another produced negative results, then at last came a heat

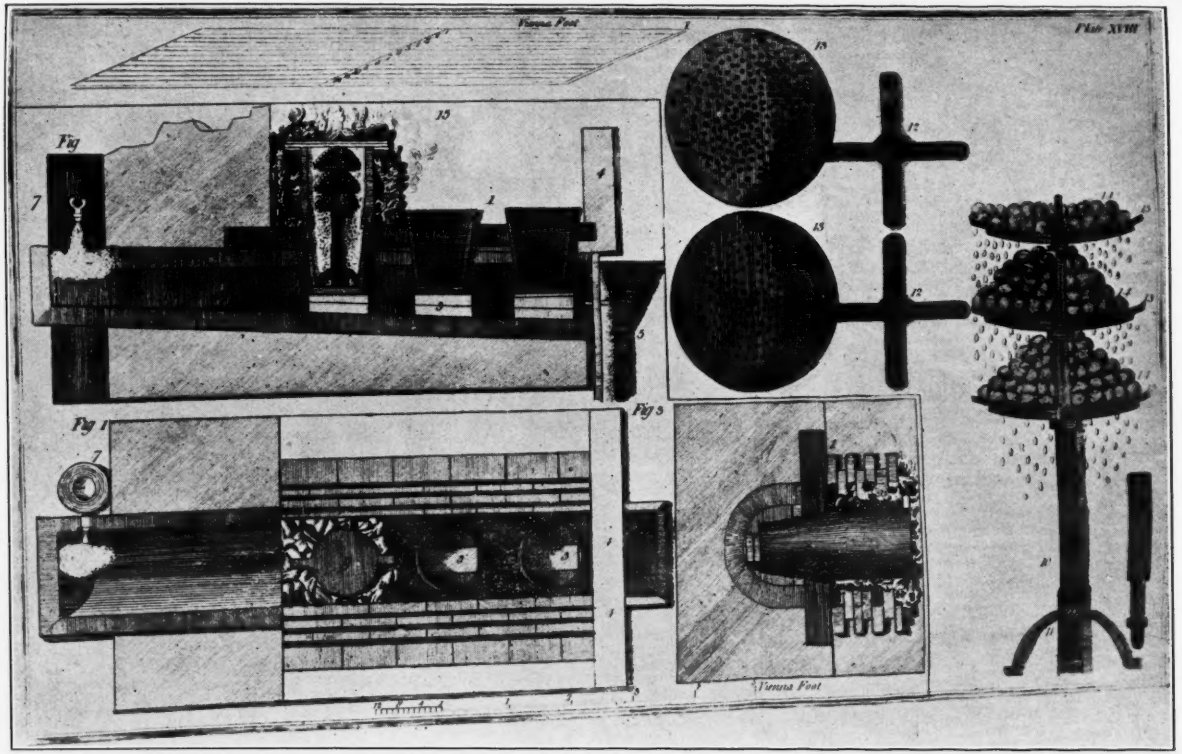
which gave a product similar to that which had inspired the experiments. The chemical in that crucible had been nitre cake, a by-product of nitric acid manufacture. Thompson bought a carload, tried it in his cupola and got the expected result. Thereupon was born the Orford Process of nickel separation, one of the two standard processes in use today.

Thompson's next stop was the U. S. Patent Office, and there he came to a full halt, his way blocked by a Connecticut cobbler who had already departed this earth. Surely, nickel was of the Devil, and "Old Nick's" gnomes were plaguing the refiner as well as the miners of old. Instead of sticking to his last this shoemaker had been brewing on the back of his kitchen stove ores from the Litchfield county mines already referred to. He had found that copper was soluble in alkaline sulfide and had filed in 1876 a patent which, in 1893, was standing in Thompson's way. Investigation proved that the shoemaker had died; that, prior to his death, he had assigned his patent to a company; and that this company was moribund. Diligent search unearthed enough stockholders to revive the company, buy from it the patent rights and then decently inter it.

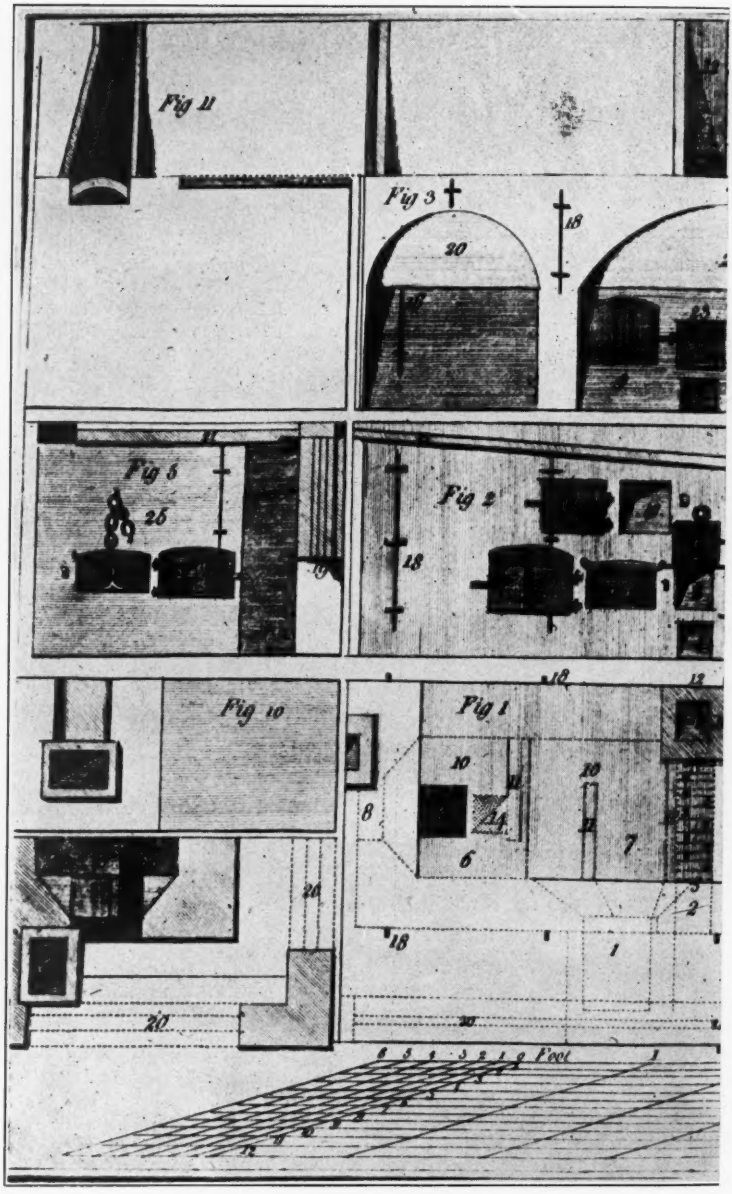
The red oxides of iron and nickel faded from the picture and the Orford Process became the cornerstone of the nickel industry. Immediately, the need for larger markets became urgent, and Colonel Thompson squared his shoulders to the task. He went to Europe where the Rothschilds, who controlled the New Caledonia output, dominated the market. He asked for a share of the European business, was refused, and cut his price. The next year he went through the same formula. The third year he was conceded a share of the market. On these trips he had letters from his Navy friends to officers in the British navy, and he made a good friend of Lord Beresford of the British Admiralty. He also made a real personal friend of Baron Adolf Rothschild, his keenest business competitor.

At about the time that Thompson was perfecting the refining method that he had stumbled upon, Dr. Ludwig Mond was working out in England quite a different process for separating nickel and copper. Here again a chance observation was the springboard. Dr. Mond and two associates were investigating the breakdown of certain valves in a plant for chlorine production. The valves had been made of nickel in the belief that this metal would resist the corrosive effects of the vapors passing through them. However, they proved leaky, and were found to be coated with carbon.

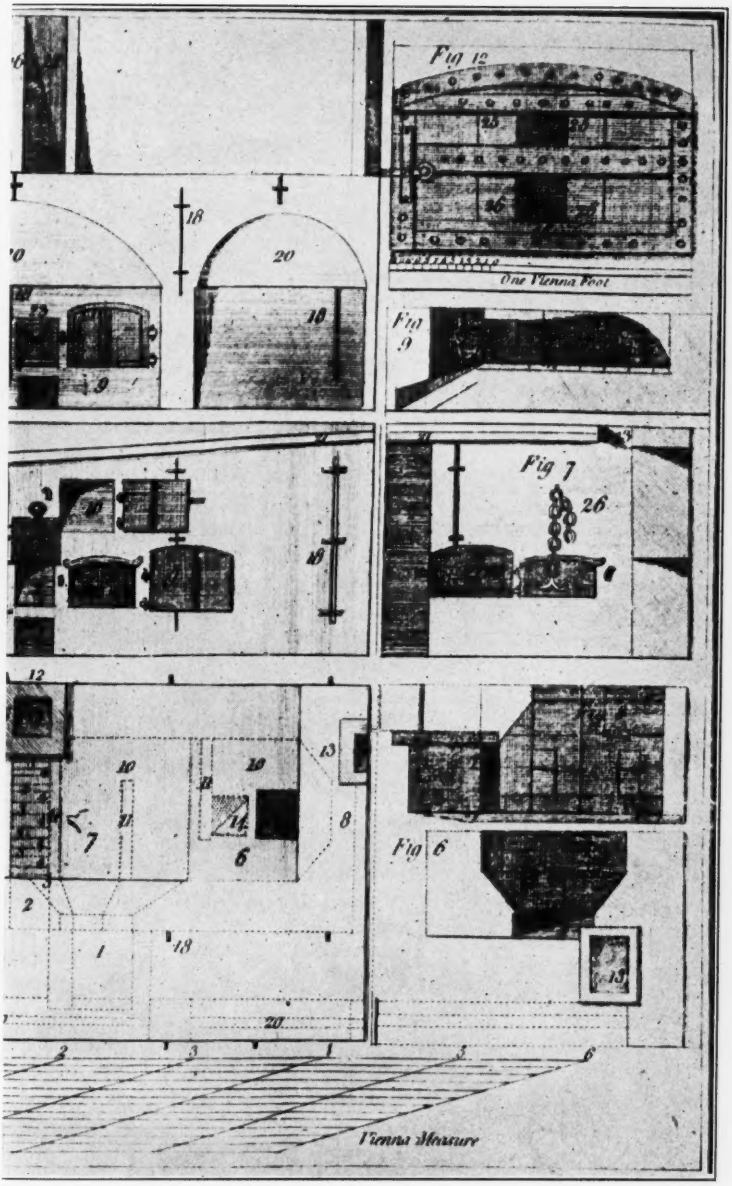
This fact led Dr. Mond to study the chemical reactions of carbon, oxygen, and nickel. In due course he discovered that finely divided metallic nickel would be picked up by carbon monoxide gas at temperatures below 50°C. to form nickel carbonyl gas, and that this gas would decompose and deposit pure nickel when heated to 200°C. From this discovery he developed the Mond, or Carbonyl, Process in which a Bessemer matte is calcined to produce mixed oxides of copper and nickel, then is treated with sulfuric acid



DESIGN OF EIGHTEENTH CENTURY HEARTH OR FURNACE
(From Baron Inigo Born's "New Process of Amalgamation," 1791.)



FRONT AND SIDE VIEW OF DOUBLE CALCIN
(Also from Baron



ING FURNACE OF SAME METALLURGICAL ERA
Born's book)

to leach out most of the copper. The nickel oxide remaining is then reduced to an impure nickel powder which is volatilized with carbon monoxide at about 50°C. The final step is to heat the carbonyl thus formed to temperatures about 200°C. so that pure nickel is deposited and carbon monoxide is re-formed.

The beauty of this process is its simplicity. However, the mechanical difficulties in handling so dangerous a gas had not been solved when the process first became known on this side of the water. Hence, although the Canadian miners obtained an option on the process and investigated it thoroughly, they finally decided not to exercise their option. Thus the British and American refiners, although using the same matte from the Canadian smelters, separate the nickel and copper by processes which employ equally effective but wholly dissimilar chemical truths.

Whether refined at Clydach, Wales, by the Mond Process, or at Constable Hook, New Jersey, by the Orford Process, the product of the Canadian ores remained in British-American hands. Krupp had already regretted his light dismissal of Ritchie's suggestion about the Gamgee alloy. The potentialities of nickel were beginning to be better understood. Hence Krupp tried to buy control of the Canadian Copper Company which was already the great producer of Canadian ores. Then the Rothschilds, already interested through their domination of the New Caledonian production, also started negotiations. At the time the Canadian Copper Company was having a critical time financially. The temptation to sell out to one or the other of these foreign interests was very real, but it is to the credit of Ritchie, Senator H. B. Payne, Henry P. McIntosh, and Judge Stevenson Burke who controlled the company, that they kept faith and, by pledging their personal fortunes and by working with the Canadian government officials, carried on. Hence, when the World War broke in 1914 and nickel became almost a precious metal, not only the properties but also the processes and personnel were British-American.

At the same time that the exploitation of the Sudbury deposits and the separation of the copper and nickel content were experiencing these growing pains, intensive research was being made into the properties and treatment of the nickel-steels. The interest of the navies in these alloys was sufficient to stimulate this activity, and the findings of the scientists were quickly translated into progressive improvements in ordnance. Industry was also awakening to the potentialities of this new factor in an age of steel. Bridge builders were not slow in reaching out for the structural benefits discovered in the nickel steels. Then the infant automotive industry turned to these alloys for the solution of many of its difficulties in engine and chassis design.

Thus, fifteen years after Ritchie was wondering how he could dispose of his metal, nickel was again in world demand. Another scant fifteen

years and the outbreak of the World War extended the Canadian mines to their limit to provide the nickel required by the Allies. Germany commandeered nickel cooking utensils and nickel-bearing coinage, reopened its old mines and stimulated Norwegian production. Although nickel-silver, nickel plating, and the coinage of pure nickel and of copper-nickel tokens was consuming larger quantities of the metal than ever, their relative importance had sunk to a small fraction of the total consumption.

The Heaven-sent material from which the blades of the individual warriors of age-old Persia had been fashioned was now being dug from the bowels of Ontario to manufacture the guns and projectiles and armor plating, the tanks and machine-gun "pill boxes," and the airplane engines of a Twentieth Century at war.

(In his next article Mr. Baldwin will tell of the collapse of the war-time market for nickel, and the introduction of the metal into peacetime industries.)

Research Shows Diet Not Responsible for Cancer. Diet is not responsible for the development of cancer, it appears from experiments reported by Sir Leonard Hill to the British medical publication, *Lancet*. Sir Leonard described his studies of mice on different diets and different beddings, which he conducted in the National Institute for Medical Research, London.

"Cancers have occurred indifferently in mice on all diets and on all beddings," he reported. "The significant influence has been age."

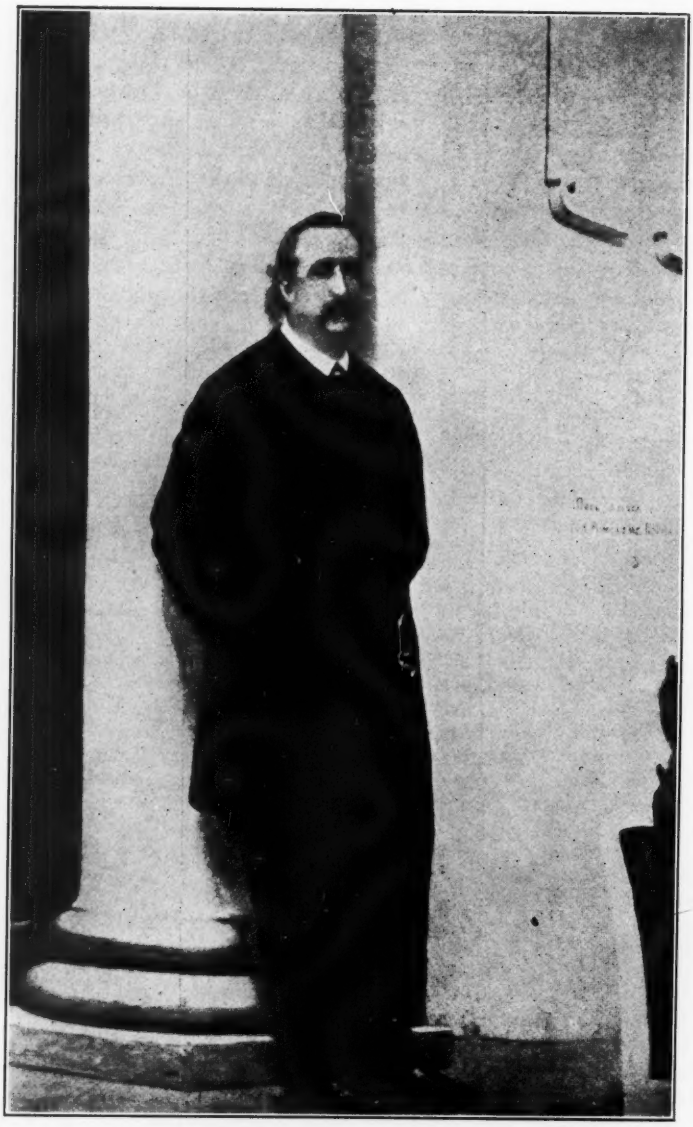
The mice were kept on five different diets as follows: an approximately natural diet for wild mice, consisting of barley, oats, wheat, and fresh green food; a canteen lunch diet of cooked meat, vegetables with the usual amount of common salt, pudding, and canned fruit; a canteen tea diet poor in vitamins, consisting of white bread, margarin, rock cakes, and biscuits; a diet found to be the average one of Essex farm laborers, low in protein value; and the same diet of which a third had been browned by frying, in order to see whether cancer-producing products were produced in food by such burning. Some of the stocks of mice were fasted two days each week to determine whether abstinence had any effect on cancer production.

While some of the diets had an effect on the size of the mice and their reproductive ability, there was no effect on the development of cancers.

Cancers occurred spontaneously in the mice, two-fifths of these tumors occurring in mice dying between the ages of one and one-half and two years. Three years in a mouse corresponds to very old age in a man, Sir Leonard pointed out. About one-third of the cancers occurred in mice dying between two and two and one-half years.

Besides reporting his investigations of mice, Sir Leonard recounted observations on the relation of cancer and diet made by other investigators. In this connection he quoted a report of the Imperial Cancer Research Laboratory as follows:

"There is no reliable evidence, experimental, statistical, or clinical, which would indicate a casual correlation between cancer and the absence, or the presence, or the excess of any particular dietetic constituent. Sensational statements to the contrary are unfounded and ill-considered, and only serve to alarm the public."—*Science Service*



PORTRAIT OF BORODIN FROM PAINTING BY RYEPIN

ALEXANDER BORODIN—CHEMIST AND MUSICIAN

FREDERICK H. GETMAN, HILLSIDE LABORATORY, STAMFORD, CONNECTICUT

Alexander Borodin (1834–87) although better known as a composer was educated as a physician and entered upon the career of a chemist. He became professor of chemistry in the Medical Academy in St. Petersburg where he spent fifteen fruitful years in the pursuit of chemical research and in training young men to become chemists. Endowed with exceptional musical talent, which had been carefully cultivated from boyhood, he produced during the spare hours of his mature years many works of musical art which are conceded to rank with the best compositions of the nineteenth century. He was also closely identified with various philanthropic causes, chief among which was the movement to secure for the women of Russia the privileges of university education.

. . . . . .

"Who can lead two lives at once?" was the question which the young musician, William Herschel, asked himself when, as organist of the Octagon Chapel at Bath, he began to realize that his earlier love for music was gradually being supplanted by an absorbing interest in astronomy. Even though Herschel became convinced of the impossibility of such a dual existence, and despite Pope's conclusion that

"One science only will one genius fit:
So vast is art, so narrow human wit,"

Alexander Borodin was able to say in middle life that "he loved chemistry as much as he did music." Although a chemist by profession he found time to cultivate his remarkable talent for music without apparent detriment to his scientific studies. At first it may seem strange that a mind which was attracted to an exact science, such as chemistry, should also be susceptible to the subtle appeal of an art like music. Yet, as one of his biographers has said: "This stimulating imaginative quality in Borodin's chosen scientific field is not, after all, so greatly in contradiction to his musical temperament."

Although Borodin is undoubtedly more widely known as a musician than as a chemist, it is nevertheless true that he never regarded music as more than an avocation, while chemistry was the subject to which he devoted himself assiduously throughout his intensely active life.

Alexander Porfirievitch Borodin was born in St. Petersburg on November 12, 1834, as the natural son of Prince Guedeanoff, a descendant of the hereditary kings of Imeretia. At the time of his birth his father was sixty-two and his mother twenty-five years of age. From these parents the child inherited the delicate constitution which proved a handicap throughout his life. It is of interest to note that just nine months before the birth of Borodin, Dmitri Ivanovitch Mendeléeff was born in Tobolsk,

Siberia. While Borodin came of royal lineage, Mendeléeff's heritage was most humble. Notwithstanding the differences in their circumstances, the two lads were destined to be thrown together as fellow students and later, through exceptionally brilliant careers, to reflect glory upon their native land.

Imeretia, the birth-place of Borodin's father, was an independent kingdom of Georgia lying south of the Caucasus Mountains between the Black and Caspian Seas. Prior to its annexation to Russia in 1810, it constituted a part of the governments of Tiflis and Kutais. The kings of Imeretia traced their lineage backward to King David; in fact the sling with which David slew Goliath, the Philistine, and the harp with which he calmed the perturbed spirit of Saul, adorned the ancient coat-of-arms of the kings of Imeretia. Who shall say that Borodin's musical gifts may not have come down to him through uncounted generations from the simple shepherd of Israel who is accredited with having been "a cunning player on the harp"? Certain it is, that to the racial stock from which Borodin sprang can be traced many of his oriental instincts together with his gift for creating exotic melodies fraught with the atmosphere of the East. Borodin's father, as a scion of Imeretian royalty, was the recipient of a liberal pension from the Russian government and was thus enabled to live a life of leisure and to devote himself to cultivating young Alexander's marked musical talent. At the early age of nine the boy began composing, and at the age of thirteen had written a concerto for flute and piano, as well as a trio for two violins and 'cello, based on themes from one of Meyerbeer's operas. He not only learned to play the piano, but also mastered the flute and violincello, and could perform creditably upon both the oboe and clarinet as well as upon several of the brass instruments. The father apparently felt that a youth of royal lineage should not enter upon a musical career and, therefore, determined that his son should be trained for the profession of medicine. Accordingly young Borodin was sent to school to prepare for his professional studies. Among the boy's classmates was a lad by the name of Schtchigleff who later became a successful teacher of music. At this time young Schtchigleff was a little prodigy and in the interval between chemistry lessons the two boys would hasten to the piano and play the symphonies of Haydn and Beethoven in duet arrangements. In due time Borodin was enrolled as a student in the Medico-Surgical Academy of the University of St. Petersburg. Notwithstanding the fact that his program of studies was a full one, he found time to attend concerts and to continue his practice of the flute and violincello. During his career as a student in the medical school it is recorded that on one occasion his love for music led him to absent himself from his classes for an entire day, and to devote nearly twenty-four hours to the uninterrupted performance of chamber music. For this he was severely reprimanded by his professor

of chemistry who charged him with "trying to hunt two hares at the same time"! This professor, none other than Zinin, the well-known organic chemist, had already recognized Borodin's natural ability and later came to regard him almost as an adopted son. Deeply conscious of the justice of Zinin's reprimand, Borodin threw himself into his work with redoubled energy and soon regained the good opinion of his teacher. Although a number of his professors feared that his passion for music might seriously hinder his success in his chosen profession, he was duly appointed surgeon to an army hospital in 1856, and two years later, at the age of twenty-four, received the degree of doctor of medicine. After a brief period of practice, Borodin was appointed to the chair of chemistry in his alma mater and shortly afterward, along with Mendelćeff and several other Russian scientific students, was sent to Europe to study chemistry under some of the eminent masters of the science.

Borodin entered upon his post-graduate studies at a time when many of the chemical doctrines which he had been taught to accept were being supplanted by newer theories. Thus, Kekulé's views on valence were rapidly taking the place of the then familiar type theory, while Cannizzaro was making his eloquent plea for the universal acceptance of Avogadro's hypothesis as a basis for a rational system of both atomic and molecular weights. Borodin and his Russian companions made their way to Heidelberg where Bunsen and Kirchoff were then perfecting their spectroscope; where Roscoe, under Bunsen's direction, was carrying out his pioneer work in the realm of photochemistry; and where Kekulé and Erlenmeyer were conducting brilliant investigations in organic chemistry. Among the young men enrolled at Heidelberg at this time, who were destined to become eminent chemists, may be mentioned Baeyer, Volhard, Lothar Meyer, Beilstein, and Quincke. With this interesting group of scientific students the young Russians were privileged to associate. Mendeléeff, with characteristic eccentricity, did not work in the university laboratory, but estab ished a small private laboratory of his own where he occupied himself with the determination of physical constants of different chemical compounds, apparently securing data upon which to base certain of the striking predictions he was later to make in connection with his enunciation of the periodic law. Borodin pursued the study of organic chemistry under Kekulé and Erlenmeyer, presumably according to Zinin's advice. He remained in Europe for three years, the greater part of which were spent in Heidelberg. During the vacations the young Russians, with knapsacks strapped to their backs, tramped far and wide. Mendeléeff gives an interesting account in his diary of one of these nomadic excursions. Thus, he wrote:

> We started with light baggage, one knapsack between two of us; we wore blouses and tried to pass ourselves off as artists, which, in Italy is always advantageous to the

traveller's purse. We bought ourselves linen en route, and when it became soiled left it by way of tips to the waiters. In this manner we visited Venice, Verona and Milan in the spring of 1860, and Genoa and Rome in the autumn of the same year. On our first trip we had an interesting adventure. Near Verona, our carriage was visited by the Austrian police in search of an Italian prisoner who had made his escape. Borodin's southern type attracted the attention of the police who believed they had found in him the man they were seeking. They ransacked our luggage from top to bottom and questioned us; but they soon found we were peaceable Russian students and thereupon left us alone. Scarcely had we passed the Austrian frontier and entered the States of Sardinia, when our travelling companions began to make much of us, to embrace us, to cry "Evviva" and to sing at the top of their voices. We then discovered that the prisoner was amongst us and had passed unobserved. Thanks to the suspicions aroused by Borodin's physiognomy, the prisoner had escaped the clutches of Austria!

During his residence in Heidelberg, Borodin spent much of his spare time in attending concerts and in making the acquaintance of musical people. It was here that he met and fell in love with Catharine Sergeievna Protopova, a Russian concert pianist. This romance culminated in the marriage of these two gifted musicians shortly after Borodin's return to Russia. In one of Borodin's letters to his wife written in later life, he recalls the days of their courtship at Heidelberg with a tenderness and passion suggestive of the letters of Robert Schumann to Clara Wieck. The entire married life of this couple proved to be a model of conjugal felicity.

Before returning to Russia, Borodin went to Paris where Wurtz was conducting his celebrated investigations in organic chemistry at the École de Medicine. It is more than probable that it was during this time that Borodin first became interested in the study of condensation reactions of aldehydes, the field of research which he so successfully cultivated in later years.

In 1862, at the conclusion of his three interesting *Wanderjahre*, Borodin returned to St. Petersburg to assume his duties as professor of chemistry at the Medical Academy. One of his students wrote in his diary the following account of the new professor:

One day a young man nonchalantly entered Zinin's private office, and soon the report was circulated in the laboratory that this was Borodin of whom we had heard much and whose return from abroad we had been expecting for some time. While Zinin was friendly with all his pupils, for Borodin he evinced a regard which was almost paternal and with him he shared his views on all current scientific topics. Borodin spent whole days in the laboratory with his students and was never too busy to answer any questions which they might wish to ask relative to their work. We could always approach him and discuss our problems with him without fear of being repulsed or receiving evasive replies. He was a man of a very even temper and his uniform consideration and kindliness of manner won our admiration and affection. The only signs of impatience which he ever exhibited were provoked by our negligence or lack of care. "Little father," he would say, "if you continue to work in that manner it will not be long before you will destroy our fine collection of apparatus." Or at another time he would exclaim, "How can you produce such foul odors in this beautiful laboratory?"

and thereupon would banish the offender to another room. His relations with his students did not cease at the threshold of the laboratory for most of us were received into his house as friends, and always took our meals there when we worked over hours. Borodin was ever on the lookout for positions for his students and it was proverbial that those requiring the services of trained chemists could not meet him without being solicited for places for his former pupils.

The year following Borodin's return from abroad he and Mlle. Protopova were married and took up their residence in the laboratory building. Their home soon became a veritable Mecca to all of his students. An interesting glimpse of Borodin's life at this time is given by his friend, Rimsky-Korsakoff, the eminent composer, who writes:

I became a frequent visitor at Borodin's; often staying over night as well. We discussed music at length and he played his projected works and also showed me sketches of his symphony. He was better informed than I on the practical side of orchestration, since he played the 'cello, oboe and flute. Borodin was an extremely cordial and cultured man, pleasant and oddly witty to talk with. On visiting him I often found him working in the laboratory which adjoined his apartment. When he sat over a retort filled with some colorless liquid and distilled it by means of a flame from one vessel to another, I used to tell him that he was "transfusing emptiness into vacancy." Having finished his work, he would go with me to his apartment, where we would resume musical operations or conversations, in the midst of which he would jump up, run back to the laboratory to see whether something had not burned out or boiled over. Meanwhile he would fill the corridor with incredible sequences of ninths or sevenths. Then he would come back and we would proceed with the music or the interrupted conversation. Catharine Sergeievna was a charming, cultured woman, an excellent pianist, and she worshipped her husband's talent.

It is quite apparent from this reminiscence that Borodin had already commenced to combine serious creative work in music with his program of teaching and chemical research.

During the decade following Borodin's return from Europe he carried out a number of important investigations, mostly in the realm of organic chemistry and in the course of these researches he discovered aldol almost simultaneously with Wurtz. In 1862 he published a paper giving an account of his experiments on the tendency exhibited by fluorides to form double compounds and on the behavior of fluorides of the organic radicals. He was led from these studies to conclude that the tendency of monatomic fluorides to form double fluorides is limited to the production of acid inorganic fluorides and double salts, and that the monatomic fluorides combine only with hydrofluoric acid. He showed that the fluorides of sodium and potassium exhibit such a marked tendency to form acid fluorides that they readily yield half of the metal to a weaker acid, as indicated by the equation

$$CH_3COOH + 2KF \longrightarrow CH_3COOK + KF{\cdot}HF.$$

The organic fluorides were found to resemble the corresponding chlorides more closely than the inorganic fluorides resemble the inorganic chlorides,

Hydrofluoric acid was shown to behave like water in its tendency to combine with solid inorganic salts, and the resulting compounds, containing hydrofluoric acid of crystallization, were found to decompose when heated.

This paper was followed shortly by another in which Borodin records the results of a study of the action of zinc ethyl on chloroiodoform. His fellow-countryman, Beilstein, a short time previously, had described a satisfactory laboratory method for the preparation of zinc ethyl and Borodin undertook an investigation of its action upon chloroiodoform. He found that when these two substances were mixed, a violent reaction ensued. In order to carry out the reaction satisfactorily, it was necessary to pre-cool an ethereal solution of the zinc alkyl and then add it drop-wise to the chloroiodoform. The reaction was found to be represented by the equation

$$3(C_2H_5)_2Zn + 2CHCl_2I \longrightarrow 2ZnCl_2 + ZnI_2 + 7C_2H_4 + 2H_2.$$

In the same year Borodin also published a brief note on the solubility of benzene in solutions of sodium ethylate. He found that when such solutions were heated they gradually lost their original dark brown color and deposited crystals of diphenylglycollic or benzilic acid, $(C_6H_5)_2{:}C(OH){\cdot}COOH$.

He next took up the investigation of aldehydes, a field of research which continued to engage his attention throughout the remainder of his life. His first communication bearing upon this subject was concerned with the action of metallic sodium on valeraldehyde. The results of this investigation may be briefly summarized as follows: sodium was found to displace hydrogen in the aldehyde, and the resulting product resembled a mixture rather than a single substitution product. On treatment with water it was found to decompose, yielding, along with sodium hydroxide, amyl alcohol and valeric acid, two other substances which, on analysis, were found to correspond to the empirical formulas, $C_{10}H_{22}O$ and $C_{10}H_{18}O$. The former compound proved to be a monatomic alcohol corresponding to capric acid, $C_{10}H_{22}O_2$. The investigation of the other product was reserved until later, and the results are described in a subsequent communication. His next paper, treating of certain derivatives of capric acid, was followed by another article on the action of sodium on valeraldehyde. In this he showed that the primary action of the metal is to remove water from the aldehyde, while secondary effects are attributed to the presence of free alkali and nascent hydrogen. Several polymers corresponding to the formulas, $(C_5H_{10}O)_n$, $C_{20}H_{38}O_3$, and $C_{10}H_{18}O$ were identified. The latter compound, which he had obtained in a previous investigation, was described at about the same time by Riban and Kekulé. On oxidation this compound was found to yield an acid, $C_{10}H_{18}O_2$, identical with an acid which he had previously isolated and identified as isocapric acid. The various condensation reactions described in these experiments may be represented by the following equations:

$$2CH_3{\cdot}(CH_2)_3CHO \longrightarrow C_{10}H_{18}O + H_2O$$
$$C_{10}H_{18}O + 4H \longrightarrow C_{10}H_{21}OH$$
$$4CH_3(CH_2)_3CHO \longrightarrow C_{20}H_{38}O_3 + H_2O$$
$$nC_{10}H_{18}O \longrightarrow (C_{10}H_{18}O)_n$$

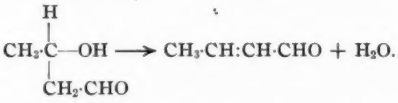
The latter polymeride was found to be an oil boiling at 250°C. The action of caustic potash at 0° was found to produce an oily polymeride lighter than water and incapable of combining with $NaHSO_3$. On distillation it yielded isovaleraldehyde and the compounds $C_{10}H_{18}O$ and $C_{20}H_{38}O_3$. The latter substance, when left in contact with a solution of sodium carbonate, was found to form a crystalline compound which, on analysis, corresponded with the formula, $C_{20}H_{42}O_5$.

When castor oil, which may be regarded as the glyceride of ricinoleic acid, is heated to a high temperature it breaks down, yielding heptaldehyde, or oenanthol, as represented by the equation

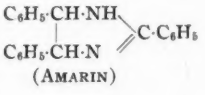
$$CH_3(CH_2)_5\underset{\displaystyle OH}{\underset{|}{C}}HCH_2CH:CH(CH_2)_7COOR \longrightarrow$$
$$CH_3(CH_2)_5CHO + CH_3CH:CH(CH_2)_7COOR,$$
(oenanthol)

where R denotes one-third of the glycerol radical. From this aldehyde, oenanthol, Borodin obtained a series of products resembling those which he had derived from valeraldehyde. By the action of solid caustic potash in the cold there were formed two polymers of oenanthol, the one a crystalline solid and the other an oil. Both were found, on distillation, to yield oenanthaldehyde and other condensation products resulting from the splitting off of water. It was during this series of investigations that he was led to study the action of hydrochloric acid on ordinary aldehyde and thus obtained aldol, according to the familiar reaction represented by the equation,

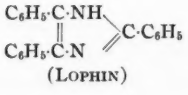
$$CH_3{\cdot}\underset{\displaystyle H}{\underset{|}{C}}:O + H{\cdot}\underset{\displaystyle H}{\underset{|}{C}}{\cdot}\underset{\displaystyle H}{\underset{|}{C}}:O \longrightarrow CH_3{\cdot}\underset{\displaystyle CH_2{-}C:O}{\underset{|}{C}}{\cdot}OH$$
$$\qquad\qquad\qquad



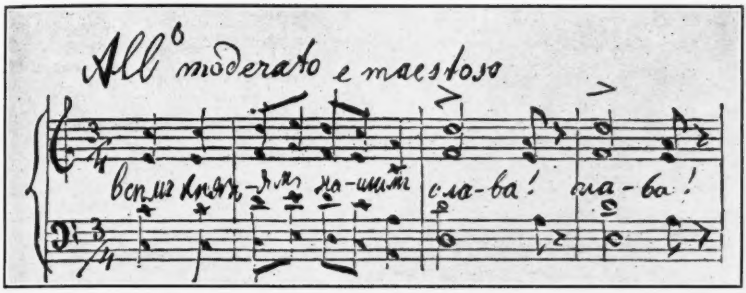
Borodin next directed his attention to the aromatic aldehydes and in the course of these studies became especially interested in the reaction between benzoic aldehyde and ammonia. It will be recalled that when ammonia and acetaldehyde are brought together they combine to form aldehyde-ammonia, $CH_3 \cdot CH(OH)(NH_2)$, whereas benzoic aldehyde reacts with ammonia to form hydrobenzamide, $(C_6H_5CH)_3N_2$. Borodin studied the transformation of this compound into amarin and at the same time sought to establish the constitution of both substances. He showed that all of the hydrogen in hydrobenzamide is bound to carbon, whereas in amarin some of the hydrogen atoms are directly attached to the ammonia residue. Since hydrobenzamide is readily converted into amarin by heating, he suggested that we have here a complete analogy with the conversion of tertiary amines into secondary and primary amines, as had previously been established by the work of Hofmann and Martius. Both cases involve the transfer of hydrogen from carbon to nitrogen, giving rise, on the one hand, to an ammonia residue and, on the other, to complex carbon groupings of a higher order. He next prepared the hydramid of cuminic acid and its isomers. He found that when the hydramid was strongly heated, or by adding aqueous ammonia to cuminol and heating to 120–130° for several days, there is formed a crystalline base which on analysis gave the formula, $C_{30}H_{36}N_2$. By the treatment of a hot concentrated solution of amarin acetate with an aqueous solution of potassium nitrate acidified with concentrated acetic acid, he obtained nitrosoamarin. On heating the nitroso compound to 150°, it was found to undergo decomposition with formation of lophin and a small quantity of liquid rich in oil of bitter almonds. While both amarin and lophin had been prepared by Laurent in 1844, Borodin's study of these compounds contributed to the elucidation of their molecular constitution as indicated by the formulas



(AMARIN)

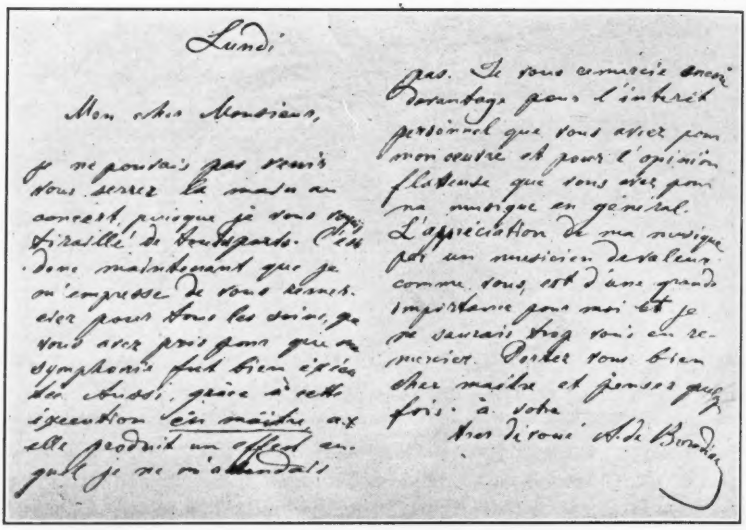


(LOPHIN)

It is to be deplored that the increasing demands upon the time and strength of this gifted man made by numerous committees, both within and without the university, should have been allowed to interfere with his chemical research and his creative work in music. While the chemical investigations we have briefly outlined constitute a valuable contribution to the science one cannot but wonder what might have been achieved

SPECIMEN OF BORODIN'S MANUSCRIPT

had his life been spared, and had he been relieved of the routine duties which a less gifted person could have performed equally well.

At about the time of Borodin's marriage he began to devote himself assiduously to the study of musical composition under the guidance of both Balakireff and Moussorgsky, and through his friendship with these two musicians was introduced to two other kindred spirits, Cesar Cui, a military engineer, and Nikolay Rimsky-Korsakoff, an ex-naval officer. It is little short of miraculous that this group of amateur musicians should ultimately come to be known as the "Great Five" of Russian composers. Early in his career as a professor of chemistry, Borodin began work on his first symphony, and during the next five years he labored spasmodically to complete it. The composition was first performed by the Russian Musical Society in 1869 and was accorded an enthusiastic reception. During the time that he was working on his symphony, Borodin also wrote a number of songs, of which "The Fair Garden," "A Dissonance," and "The Sea," are especially noteworthy for their originality and charm. He would commence work on a composition and then suddenly abandon it to develop some other musical conception which for the moment seemed more promising. Thus, we find him launched on the high sea of opera and then sailing on the quiet waters of song. By the end of 1876, however, he had completed his second symphony and early in the following year it had its première in St. Petersburg. A competent critic wrote of this performance: "Of Borodin's two symphonies the second is the greater work, and owes its force to the maturity of the composer's talent and especially to the national character with which it is impregnated by its program." In 1877 Borodin made another trip to Europe, visiting Weimar in the course of his journeyings. Here he met Franz Liszt who greeted him most cordially with the words: "Only two days ago I played your symphony to the Grand Duke who was charmed with it. The first movement is perfect. Your *Andante* is a masterpeice. The *Scherzo* is enchanting." Later Liszt placed Borodin, whom he called, "The Chemist from St. Petersburg,"



LETTER FROM BORODIN TO MONSIEUR TH. RADOUX, DATED JANUARY 25, 1886

Translation

Monday

My dear Sir:

I could not come to shake your hand after the concert because I saw you were being jostled on all sides.

Hence it is that I now hasten to thank you for all the care you took in order that my symphony should be well performed. Also thanks for the *masterly manner* in which it was executed thereby producing a result beyond my expectation.

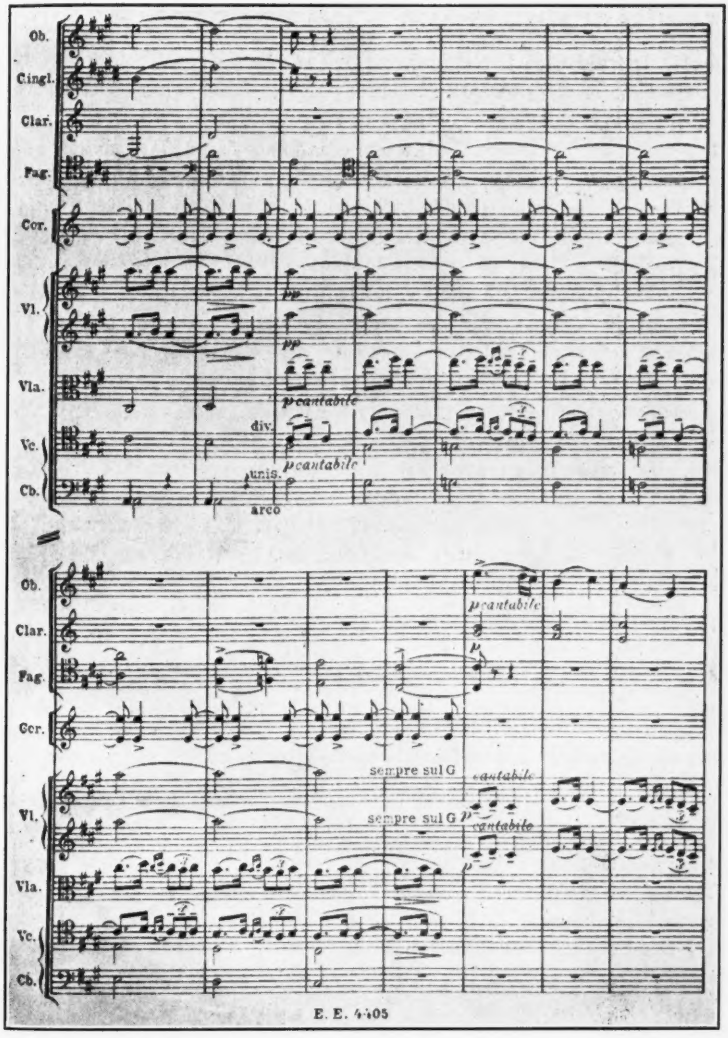
I do thank you much more for your personal interest in my work and the flattering opinion you have of my music as a whole. Appreciation of my music by a musician of note like yourself is of great value to me and I cannot be too grateful to you.

Take good care of your health dear master and think sometimes of

Your devoted
A. Borodin

among the greatest musicians of the age and used his influence to make the works of this young Russian better known in Europe.

Shortly after returning from his visit to Liszt, he resumed work on opera, "Prince Igor," but soon laid it aside to write the familiar symphonic poem, "On the Steppes of Central Asia," which was destined to become the most popular of all his musical creations. In 1880, in connection with the celebration of the silver jubilee of Czar Alexander II, a series of tableaux illustrative of Russian history were given in the Imperial Theatre. One of the musical numbers rendered on this occasion was Borodin's symphonic poem descriptive of a caravan crossing the vast expanse of the Russian Steppes under a guard of soldiers. This fascinating tone poem has been briefly described by F. H. Martens in the following words:

Below the long continued notes of the violins, which express the arid monotony of the endless plain, moves a peaceful Russian folk-tune, presented by the clarinet, and subsequently taken up by the horn. From the distance comes the sound of trampling

PAGE FROM SCORE OF "DANS LES STEPPES"

hoofs and accompanying it, a plaintive oriental melody. As the caravan advances, the Russian melody swells in volume and then dies away again as it recedes in the distance. Then the aboriginal Mongol melody is heard once more mingling with the occidental folk-air, until both are lost in the far reaches of the sandy sea.

It has been said that the epic strength and the Oriental coloring of the orchestration in this symphonic poem place it among the most notable musical achievements of the nineteenth century.

The opera, "Prince Igor," although commenced in 1871, was not completed during the composer's life; fortunately, however, the work had been fully sketched and enough of the orchestration completed so that two of his friends, Rimsky-Korsakoff and Glazunoff, were able to finish it. The opera had its première in St. Petersburg in 1890 and its first rendition in New York in 1915; in both cities it received an ovation.

In addition to the larger works we have mentioned, Borodin wrote a number of lesser compositions possessing that Oriental character which lends a peculiar charm to all of his music.

In order to appreciate the colossal genius of this man it must be emphasized that his musical activity was confined to his leisure hours, and that he never regarded music in any other light than as a pastime. He very modestly referred to himself as a "Sunday musician," and in speaking of his opera, said: "Igor is my natural child: I take care to keep him well hidden!" His incessant labor weakened his none-too-strong body but, nevertheless, he accepted illness most philosophically and made light of poor health. On one occasion when confined to his apartment with an attack of grip, he said:

> In winter I cannot compose unless I am sick and obliged to give up my lectures. So my friends, contrary to custom, never say to me, "Try and keep well!" but rather, "Try and fall sick!" When my head is bursting, when my eyes are filled with tears and I have to take out my handkerchief every minute, then it is that I compose.

Borodin was among the first to recognize the injustice done to the women of Russia by withholding from them the educational and social privileges accorded to its men. He, therefore, espoused the cause of university education for Russian women and, from 1872 until the day of his death, gave gratuitous instruction in chemistry at the Medical School for Women which had been established through the efforts of Professor Rudneyeff and Madame Farnooskaya.

Although the Borodins had no children of their own, they were continually adopting unfortunate and orphan children and bringing them up. Their hospitality and sympathy for the poor and needy made their home a veritable eleemosynary center in the city of St. Petersburg. Money was apparently a matter of indifference to this kindly couple and without pretense or formality they welcomed all who came to their door.

Borodin's wife was a sufferer from asthma and in the summer vacations it became their custom to migrate to the country where, in a rented *izba* or peasant's hut, they lived the simple life. One of their musical friends who paid them a visit during one of these periods of rustication wrote a description of their life in the following words:

> At their summer home they live queerly. They usually rent an *izba* without having seen it. They bring with them few belongings, have no hearth plate and do their cooking in a Russian oven. Their mode of living is extremely uncomfortable in crowded quarters with all kinds of privations. The ever-sickly Catharine Sergeievna goes barefoot all summer long for some reason.

Nevertheless, it was this simple manner of life which he lived during his summer vacations that enabled him to recuperate for the strenuous days and nights of the academic year and the ever-increasing demands of his official and outside duties.

Rimsky-Korsakoff gives a vivid picture of Borodin's home life and its distractions as he saw it shortly before Borodin's death; from this we quote as follows:

> Rarely did I find him in his laboratory, still more rarely at composition or at the piano. Usually it turned out that he had just gone to or was just returned from a meeting; that he had spent all day driving about on those same errands, or else had been writing business letters, or working over his account books. Add to these (activities) his lectures, the various meetings of the academic conference and other meetings, and it will become clear that there was no time at all left for music. Thanks to the charitable hurly-burly, his time was frittered away on trifles that could have been attended to by such as were not Borodins. Moreover, knowing well his kind and easy-going nature, medical students and all sorts of student-youth of the fair sex, besieged him with every manner of solicitation and request, all of which he tried to fulfil with characteristic self-denial. His inconvenient apartment, so like a corridor, never allowed him to lock himself in or pretend that he was not at home. Anyone entered his house at any time whatsoever and took him away from his dinner or his tea. Dear old Borodin would get up with his meal or his drink half-tasted, would listen to all sorts of requests and complaints and would promise to "look into it." To this must also be added that Catharine Sergeievna was a constant sufferer from asthma, passed sleepless nights and frequently arose at midnight. Alexander Porfirievitch had a difficult time with her at night, rose early and did not have sufficient sleep. Their whole home life was one unending disorder. Dinner time and other meal times were most indefinite. Once I came to their house at eleven in the evening and found them at dinner. Leaving out of account the girls, their protegées, of whom the house had never any lack, their apartment was often used as a shelter or a night's lodging by various poor (or visiting) relations who picked that place in which to fall ill or lose their minds. Borodin had his hands full with them but he doctored them, took them to hospitals and then visited them there. In four rooms of his apartment there often slept several strange persons of this sort; sofas and floors were turned into beds. Frequently it proved impossible to play the piano because some one lay asleep in the adjoining room. At dinner and tea, too, great disorder prevailed. Several tom-cats that found a home in Borodin's apartment were wont to parade across the dinner-table, sticking their noses into plates and unceremoniously leaping onto the diners' backs. These cats basked in Catharine Sergeievna's protection; various details

of their biography were related. One tabby was called *Rybolov* (Fisherman) because in the winter, he managed to catch small fish with his paw through the ice-holes; another was called *Dlinyenki* (Lanky) and he was in the habit of fetching homeless kittens by the neck to the Borodin's apartment and they in turn would harbor them until they could find a home for them. Then there were other and less remarkable specimens of the *genus felis*. You might be sitting at their tea-table—when behold! Tommy marches along the board and makes for your plate; you shoo him off, but Catharine Sergeievna invariably takes his part and tells some incident from his biography. Meantime, zip! another cat has bounded at Alexander Porfirievitch's neck and twining itself about it, has fallen to warming that neck without pity. "Listen, dear Sir, this is too much of a good thing!" says Borodin, but without stirring the cat lolls blissfully on. Borodin was a man with no whims and easy to get along with. He slept little, but could sleep on anything and anywhere. He could dine twice a day, or go dinnerless altogether, both of which happened frequently. He would drop in on a friend during dinner and being invited to join in the meal, he would say, "As I have already dined today, and, consequently, have formed the habit of dining, I might as well dine once more." He would be offered wine and would reply, "As I don't drink wine as a rule I may treat myself today." Next time it might be just the contrary. Having vanished and remained lost all day, he would drop in at evening tea and calmly sit down near the samovar. His wife would ask him where he had dined and only then would he recollect that he had had no dinner at all. Dinner would be served, and he would eat it with gusto. At evening tea he would drink cup after cup without counting and when his wife would ask him if he would have another he would ask, "How many have I had?" and on being told would reply, "Well, then I've had enough."

Borodin's death occurred with tragic suddenness on the evening of February 16, 1887. He had invited a group of friends to his apartment to celebrate the closing of the mid-winter carnival. He played for them excerpts from his third symphony, which he was then writing, after which informal dancing was proposed and Borodin, who was an excellent dancer, welcomed the proposal with youthful enthusiasm. Later in the evening, while engaged in an animated conversation with one of his guests, an ominous pallor suddenly overspread his countenance; he tottered and fell to the floor. Medical assistance was promptly summoned and restoratives were administered but without avail, instant death having ensued as the result of aneurism of the heart. Thus, at the height of a brilliant career and in the midst of a life of exceptional usefulness,

> "A soul, that in music, as a flower in light,
> Did'st gem and bloom and vanish with a breath."

Borodin was buried in the cemetery of the Alexander Nyevsky Monastery, not far from the graves of Dostoievski, Tschaikowski, and Rubinstein. On his casket was a silver plate, sent by the women physicians to whom he had given gratuitous instruction, and on this plate was inscribed:

> "To the founder, protector and defender
> of the School of Medicine for Women."

GRAVE OF BORODIN

The grave of Borodin is marked by an interesting memorial given by his many friends and admirers. In designing this monument, the artist has sought to epitomize the outstanding achievements of this singularly talented man. A rather elaborately carved and slightly recessed granite shaft serves as the background for a finely sculptured bronze bust of Borodin. Directly behind the bust, selections from the composer's music are reproduced in exquisite mosaic. It is of interest to note the excerpts chosen by the artist; they are—the opening theme of the first symphony, the chorus of the Polovtsian women from "Prince Igor," the first bars of the "Chanson de la Fôret Sombre," the opening theme of the Scherzo in the third symphony, and the first notes of the symphonic poem, "Les Steppes." On the face of the pedestal upon which the bust rests there is a carved representation of a *kobza*, an instrument with which the Muscovite troubadors accompanied their folk-songs. Borodin being very familiar with many of these native songs and having derived some of his best thematic material from this source, it is appropriate that this symbol of early Slavic music should be wrought into the design of the monument. An elaborate railing of iron surrounding the tomb carries at its center a circular shield which bears around its circumference the empirical formulas of the various chemical compounds isolated by Borodin. Separating the grave from the adjoining burial plot is another iron railing in the border of which the artist has incorporated yet another of the composer's themes.

As one reflects upon the career of this man of many talents, who was ever ready to aid the underprivileged, or to minister to those in distress, despite the allurements of both science and art, one finds it difficult adequately to appraise his contributions to his fellowmen. Some one has said of him:

> Borodin, in the nineteenth century, seems like one of those saintly figures, which medieval legend has made familiar to us. He was. . . .without any thought of worldly gain or advantage, full of the spirit of self-sacrifice. He lived like an apostle and almost like an anchorite.

His life was one

> "Of toil unsevered from tranquility!
> Of labor, that in lasting fruit outgrows
> Far noisier schemes, accomplished in repose
> Too great for haste, too high for rivalry!"

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"Chez ceux- la et chez nous" (with orchestra or piano).
"Dans ton pays, si plain charmes."
"Arabe, Si tu fuis mes regards."
"Snow-white."
"The Wrong Note."
"Fleurs d'Amour."
"Das Meer rauscht und stürmt."
"Mon Chant est amer et sauvage."
"La Reine de la Mer."

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Acknowledgment

The author desires to acknowledge his indebtedness to the publisher, Alfred A. Knopf, for permission to reproduce the portrait of Borodin taken from Rimsky-Korsakoff's "My Musical Life," and to Mr. D. D. Berholzheimer for his generous assistance in securing the photograph of Borodin's monument.

Fish Flour. The new method of marketing frozen fillets of fish involves the production of a considerable amount of edible quality white fish scrap. What more natural than that this edible by-product should find its way into our food?

For many years, fish scrap of medium grade has been dried and ground and used as a supplementary food for farm animals. It has been found particularly desirable in the diet of chickens because it stimulates their growth and, later, egg production. It is also said to be excellent for the development of young calves and pigs.

Fish meal, besides its content of 65% or more of protein, contains highly desirable mineral salts, including calcium phosphate, and small yet important amounts of elements such as iodine and copper, which are essential to life and development. Vitamin content is still controversial, but the value of fish meal as auxiliary food is established. The Agricultural Station of the State of New Hampshire, and others, have claimed that as little as five per cent of fish meal in an otherwise deficient diet prevented rickets in chickens.

When white fish scrap is fed to cows, pigs, or chickens, no fishy taste is imparted to the milk, meat, or eggs, an objection met only when using oily meal such as is obtained from herring.

The non-oily white fish scrap which is now being experimented with in flour form for human consumption has pleasant taste and odor, which may, if desired, be easily disguised, and good white color. It should find convenient use in purées, chowders, and croquettes, while its partial substitution for wheat flour in crackers should provide new types of bakery products of high protein value. According to *Science Service*, as much as 15% may be used in substitution for white flour in spice cookies, and this without other deviation from regular formulas.

Fish flour promises, therefore, to provide an economical source of protein in our dietary. It may have special value as supplying mineral materials in generous amount, and especially those traces of chemical elements, all too scarce in most parts of the country, which are obtainable from sea foods.—*Ind. Bull., Arthur D. Little, Inc.*

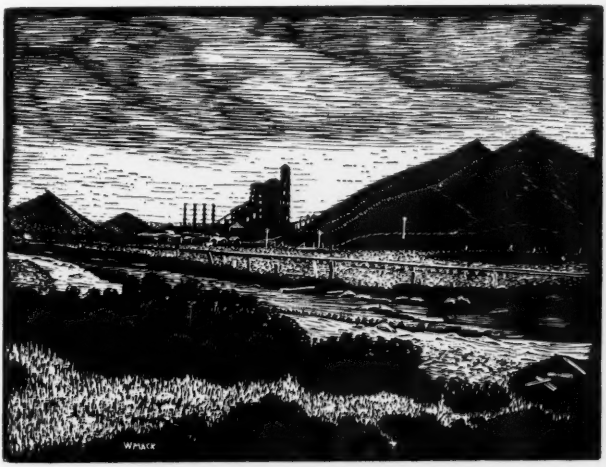
THE FIRST-YEAR CHEMISTRY COURSE

PAULINE G. BEERY,* THE PENNSYLVANIA STATE COLLEGE, STATE COLLEGE, PENNA.

In my mind, teaching is not merely a life work, a profession, an occupation, a struggle; it is a passion. I love to teach. WILLIAM LYON PHELPS

The teaching of the first-year chemistry course in college or high school can be either the most delightful or the most deadening of tasks. The teacher whose classes are merely periods to be passed bores himself even more than he does his students. But the teacher who welcomes the opportunity to introduce his students into one of the most interesting of all sciences experiences satisfaction like that of the bearer of good news.

The teacher who loves to teach first-year chemistry uses his textbook as a servant. He enriches the textbook material, which of necessity is pre-



COAL IS SOMETHING MORE THAN A BLACK SOLID WHICH BURNS

sented in a formal manner, by news items of timely interest, journal articles on related subjects, motion pictures, and trips to manufacturing plants. By so doing he does not find it necessary to place less emphasis on the fundamental principles of the subject. On the contrary, he finds his students better able to understand and more anxious to learn the laws and theories of the subject for having obtained first-hand information on their practical applications.

The teacher of first-year chemistry who does not make the subject alive for his students is a slave to the textbook. To him its chapters are but a series of duties to be done in preparation for the final examination which

* Associate Editor, in charge of *The Chemistry Leaflet.*

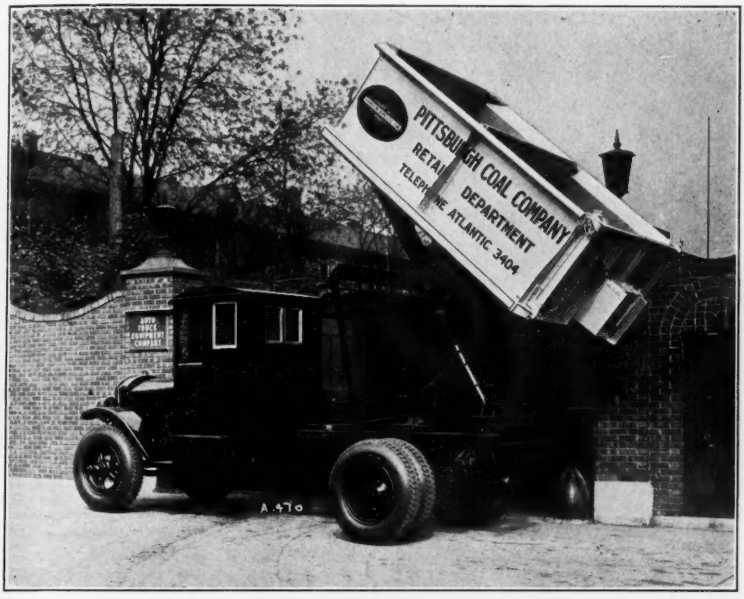
marks the conclusion of a distasteful experience. To him a piece of coal is a black solid; it has certain physical characteristics; it burns with the evolution of a certain number of heat units per unit of weight; and the amount of heat which it generates can be measured in a so-called calorimeter, thus giving data for solving a certain type of problem. To the live teacher of first-year chemistry, coal does all of these things and more. It serves as nature's storehouse for a host of important materials which feature in many every-day affairs.

It was for the purpose of making it possible for teachers of chemistry to assist each other to be better teachers that the Division of Chemical Education of the American Chemical Society was formed. In order to provide tangible means by which an interchange of ideas can be effected, the Division publishes the JOURNAL OF CHEMICAL EDUCATION for teachers, and *The Chemistry Leaflet* for students of chemistry.

The JOURNAL OF CHEMICAL EDUCATION serves as a clearing house for information which should be of interest to teachers of all phases of chemistry. The various issues of THIS JOURNAL contain many types of articles: special subject-matter articles giving the story of various interesting materials, each written by a person who has first-hand information on the subject; articles on interesting ways of presenting difficult chemical subjects; notes on new kinds of apparatus for demonstrating old principles; historical articles showing the development of the science; articles on the newer chemical theories; abstracts of new books and of articles from other periodicals; and news items concerning recent happenings in the chemical field and the doings of chemists. It is issued once each month.

The Chemistry Leaflet, the student publication of the Division of Chemical Education, is issued once each week during the school year (thirty-four issues). Its purpose is two-fold: (1) to provide interesting items from a wide variety of sources on the subject which the student is taking up in class during the week; and (2) to serve as a medium for the exchange of ideas between the many student chemistry clubs which are now to be found in our colleges and high schools.

The calendar for Volume V of the *Leaflet* for the school year 1931–32 was made after studying the sequence of topics of a large number of first-year high-school and college chemistry textbooks. It is believed to represent a cross-section of the great majority of these texts. Whereas this schedule places considerably more emphasis on the metals than is the case with the average high-school text, it is believed that this is not undesirable. The high-school text is inclined to devote too little attention to the metals in the light of their ever-increasing every-day importance. *The Chemistry Leaflet* will therefore provide material with which the student can supplement the meager textbook treatment of the metals, and enjoy himself while doing so.



ALUMINUM ALLOYS SERVE AS EXCELLENT STRUCTURAL MATERIALS FOR TRUCK BODIES

The uses of aluminum are better understood after looking at pictures such as this. Subject-matter articles in the JOURNAL OF CHEMICAL EDUCATION serve to make the reader personally acquainted with the material under discussion.

One of the questions which teachers of first-year chemistry ask most frequently is this: "How can I use the JOURNAL OF CHEMICAL EDUCATION and *The Chemistry Leaflet* in my elementary chemistry courses?" In order to answer this question, an outline has been prepared, merely by way of suggestion, in which the subjects of Volume V (1931–32) of *The Chemistry Leaflet* serve as the backbone. Under each of these subjects there is presented a list of articles in past issues of the JOURNAL OF CHEMICAL EDUCATION on closely related subjects. Articles are included in this list which should be valuable either for the teacher's information or as reference material for students. ***Teachers who have been subscribers to the Journal for some time, but who have never made a card index of its articles, should find this a convenient help in starting such an index.***

In order to help the teacher to secure visual aids which will make first-year chemistry more real to students, a group of slides and of motion pictures has been selected for each subject. These were taken from lists compiled by the Committee on Visual Aids in Chemical Education, an important committee of the Division of Chemical Education. The slides

and motion pictures selected in each case by no means exhaust the number in the published lists of the committee. The original lists may be found in a series of articles issued by the Committee and appearing in the JOURNAL OF CHEMICAL EDUCATION, Volume VII, pages 823, 1113, 1341, and 2916; and in Volume VIII, page 128.

The costs of the slides are not listed, but may be obtained by communicating with the companies which have them for distribution. The motion pictures are for free loan unless otherwise stated.

Many teachers of first-year chemistry are finding it possible to supplement the work of the classroom by the activities of the student chemistry club. When time is at a premium, a well-organized club can be used as a means of allowing the students to present subject matter of timely interest, show motion pictures, or take an inspection trip correlated with the classroom topic which is being considered at the time. Students do not lose interest in chemistry club affairs because the topics are related to their classroom work. In fact, this arrangement is likely to have quite the opposite effect.

The chemistry club programs suggested in the accompanying outline are merely by way of showing a few of the numberless possible activities in which a student club can participate with profit and pleasure.

No. 1.* WATER AND ITS ELEMENTS (September 10, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

The Water Supply, **5,**** p. 1671
Water Purification and Water Softening at Columbus, Ohio, **4,** p. 945
The Vapor Density of Steam, **6,** p. 107
Demonstration of the Claude Method of Obtaining Power from Warm Sea Water, **8,** p. 934
Hydrogen and Oxygen, **5,** p. 1152
Hydrogen Balloons, **7,** p. 2719
Explosion of Oxygen and Hydrogen, **8,** p. 929
Class Production of the Oxy-Hydrogen Flame, **8,** p. 929
Atomic Hydrogen Flame, **4,** p. 39
Method of Determining Amount of Oxygen in Air, **5,** p. 741
A Method for the Quantitative Determination of Oxygen in the Atmosphere, **6,** p. 105
A Rapid Determination of Oxygen in the Air, **4,** p. 638
Friendly Fire, **6,** p. 1787
Why Does a Substance Burn? **6,** p. 965
Combustion, **7,** p. 1159
Combustion Demonstrations, **4,** p. 914
Experiments on Spontaneous Combustion, **8,** p. 930
Doctrine of Phlogiston, **2,** p. 743

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* Numbers 1 to 34 in this outline are the topics of the issues of *The Chemistry Leaflet* for the school year 1931–32. The dates of each issue are listed with the topic.

** The boldface numbers represent the volume numbers.

Special Priestley Number, **4,** pp. 141–99, including such articles as "Joseph Priestley as a Historian," "History of the Priestley House," "Birth of the American Chemical Society at the Priestley House," "Priestley's Life in Northumberland," and "One of Priestley's First Letters."

Determination of the Molecular Weight of Oxygen, **8,** p. 1858.

Visual Aids

Slides

16 Slides on Oxygen (*W. M. Welch Scientific Co., 1516 Orleans Street, Chicago, Ill.*)

17 Slides on Water (*same company*)

10 Slides on Hydrogen (*same company*)

60 Slides on "The Chemistry of Water Treatment" (*International Filter Co., 59 East Van Buren St., Chicago, Ill.*)

Motion Pictures

Steam Power (Mechanical Stoker) (1 reel, 16 mm.) (for sale) (*Eastman Teaching Films, Inc., 343 State Street, Rochester, N. Y.*)

Chemistry of Combustion (1 reel, 35 mm.) (*University of Wisconsin, Madison, Wis.*)

Oxygen the Wonder Worker (2 or 4 reels, 35 mm.) (*Air Reduction Sales Corporation, 342 Madison Avenue, New York City; Bureau of Mines, 3800 Forbes Street, Pittsburgh, Penna.; Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st Street, New York City, also 300 W. Adams Bldg., Chicago, Ill.*)

Oxygen Breathing Apparatus (1 reel, 35 mm.) (*Bureau of Mines, 4800 Forbes Street, Pittsburgh, Penna.*)

Fire Making (1 reel, 16 mm.) (sale only) (*Eastman Teaching Films, Inc., 343 State Street, Rochester, N. Y.*)

Magic Flame (4 reels, 16 and 35 mm.) (*Gas Products Association, Chicago, Ill.*)

Stoker Combustion (2 reels, 35 mm.) (*University of Wisconsin, Madison, Wis.*)

Suggested Chemistry Club Programs

Option (1). A Meeting in which "Water and Its Elements" serves as the topic of the program, with various reports and demonstrations suggested by reading Vol. V, No. 1, of *The Chemistry Leaflet* and the above-mentioned articles from the JOURNAL OF CHEMICAL EDUCATION.

Option (2). Presentation of the chemical play "The New Assistant" (J. CHEM. EDUC., **2,** p. 600).

Option (3). Presentation of any of the general chemical plays listed at the top of page 1787 of this article.

No. 2. SPECIAL CHEMISTRY CLUB NUMBER (September 17, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

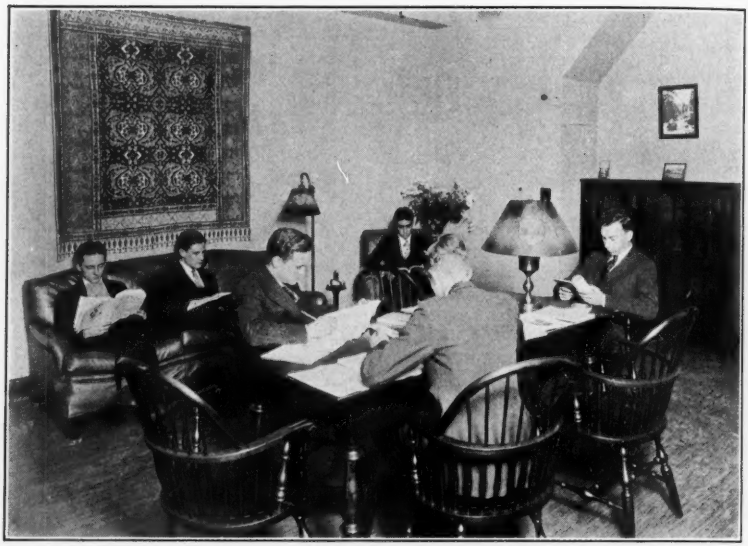
This number of *The Chemistry Leaflet* will be devoted exclusively to the organization of the student chemistry club. Suggestion for names, a chemistry club constitution, and suggestions for programs will be given. In addition to the material contained in this issue, attention is called to the following articles on Chemistry Clubs which have appeared in past issues of the JOURNAL OF CHEMICAL EDUCATION.

What a Chemistry Club Can Do, **5,** p. 1335

Organization of Science Clubs, **1,** p. 31; **3,** pp. 462, 576; **6,** pp. 496, 958; and **7,** p. 1327

Chemistry Club Program, **2,** p. 294

Chemistry Club Work, **7,** p. 1115



IF THE CHEMISTRY CLUB CAN SECURE A CLUBROOM, IT IS INDEED FORTUNATE
Clubroom of the Student Chemistry Club at Brown University.

A Successful Science Club Initiation, **6,** p. 958
Activities of Chemistry Clubs, **4,** p. 1037
Fostering Science Clubs in the High School, **6,** p. 496
Chemistry on the High-School Stage, **6,** p. 963

The holding of meetings should by no means constitute the sum total of the activities in which a student chemistry club should participate. Miscellaneous worthwhile activities are suggested in the following articles from past issues of the JOURNAL OF CHEMICAL EDUCATION.

Student's Research Work in High-School Chemistry, **4,** p. 1241
Suggestions of Suitable Pictures for the Science Classrooms, **2,** p. 111
The Chemistry Open House, **5,** p. 531
A Chemistry Exhibit, **5,** p. 280
Chemistry Exhibits in the Small Laboratory, **7,** p. 1649
A Science Fair, **8,** p. 244
Chemical Museum Exhibit, **6,** p. 730
A Chemistry Club's Contribution to Its University, **6,** p. 2008
A Chemistry Clubroom, **7,** p. 891
Posters in Chemistry, **2,** p. 792; **5,** p. 157; **6,** p. 1535
Chemical Spelling, **2,** p. 462
The Game of Chemists, **7,** p. 636

New Chemical playlets will appear frequently in the forthcoming issues of the JOURNAL OF CHEMICAL EDUCATION and in *The Chemistry Leaflet.* In order that a club may have a file of plays and burlesques from which to draw early in the year, the following references to the JOURNAL OF CHEMICAL EDUCATION should be noted.

The Arabian Barber Shop, **6,** p. 2011
The Fraternity Initiation, **6,** p. 2254
Play—A Night in Alchemy, **5,** p. 715
Chemistry Saves the Day, **7,** p. 164
How Times Have Changed—A Playlet in Two Acts, **8,** p. 256
Interference—A Chemical Playlet, **4,** p. 905

An excellent movie for an early chemistry club program may be found in Chemistry (35 mm., 1 reel) picture made by the *University of Wisconsin, Madison, Wisconsin.*

No. 3. THE CONSTITUTION OF MATTER (September 24, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

The Nature of Matter, **5,** p. 1135
The Street of the Alchemists, **5,** p. 467
Alchemy: Folly or Wisdom? **7,** p. 2664
Science in the Modern World, **7,** p. 1061
Reality of the Atom, **4,** p. 327
John Dalton, **3,** p. 485; **4,** p. 23
Cannizzaro and the Atomic Theory, **4,** p. 836
The Centenary of Cannizzaro, **3,** p. 1361
How Small Is a Molecule? **6,** p. 1797
A Simple Illustration of the Law of Mass Action, **5,** p. 279
An Experiment to Illustrate the Law of Multiple Proportions, **6,** p. 1759
Training in Writing Chemical Equations, **7,** p. 2127
Molecular Models, **6,** p. 1984
Chemical Bank, **6,** p. 1790
The Displacement Series, **5,** p. 733; **7,** p. 1895
The Combining Weight of Copper, **5,** p. 223
Combining Ratio of Copper and Sulfur, **5,** p. 1129
Metric System, **2,** p. 593
Helping the Metric Campaign, **2,** p. 62
Weights and Measures in "Work of the Bureau of Standards," **3,** p. 7
Faraday's Contribution to Chemistry, **8,** p. 1493
An Experiment Illustrating the Law of Mass Action, **8,** p. 1522

Visual Aids

Slides

8 Slides on Introduction to Chemistry (*W. M. Welch Scientific Co., 1516 Orleans St., Chicago, Ill.*)
15 Slides on Atoms and Molecules (*same company*)
23 Slides on The Chemical Industry (*General Electric Co., 1 River Road, Schenectady, N. Y.*)
58 Slides on History of Chemistry (*Bureau of Visual Instruction, University of Kansas, Lawrence, Kan.*)

Motion Pictures

Beyond the Microscope (1 reel, 16 mm.) (*General Electric Co., 1 River Road, Schenectady, N. Y.*); (35 mm.) (*Acme Educational Film Service, 1132–1136 W. Austin Avenue, Chicago, Ill.; Indiana University, Bloomington, Ind.; Iowa State College, Visual Instruction Service, Ames, Ia.; University of Wisconsin, Madison, Wis.*)

WHEN SCIENTISTS MAKE NEW CONTRIBUTIONS TOWARD UNRAVELING THE SECRETS OF THE STRUCTURE OF MATTER, AN EFFORT IS MADE TO PUBLISH THE NEW FINDINGS IN A FORM SUITABLE FOR PRESENTATION IN THE ELEMENTARY CLASSROOM

Suggested Chemistry Club Programs

Option (1). A meeting in which the topics of Vol. V, No. 3, of *The Chemistry Leaflet* are discussed.

Option (2). Playlet—A Night in Alchemy (J. CHEM. EDUC., **5**, p. 715).

No. 4. ATOMIC STRUCTURE AND THE PERIODIC TABLE (October 1, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

The Structure of Matter, **5**, pp. 1152, 1312, 1473, 1639; **3**, pp. 1110, 1254, 1426; **4**. pp. 73, 220
Laboratory Exercise in Atomic Structure, **1**, p. 100
A New Method of Teaching Atoms and Molecules, **2**, p. 248
Determining Molecular Weights, **8**, p 546
Atoms, Molecules, and Ions, **5**, p. 25
Atomic Model Contest for High Schools, **8**, p. 140
Adjustable Atomic Model, **2**, p. 499
Construction and Use of Models in Chemistry, **5**, p. 193
Electron Concept, **2**, p. 576
Molecular Speed, **5**, p. 1484
A New Form of Periodic Table, **1**, p. 173
A Model of the Periodic Table, **2**, p. 107
Compact Arrangement of the Periodic Table, **2**, p. 381
New Periodic Table of the Elements, **3**, p. 1058
Electromotive Series and Periodic Table, **4**, p. 228
Another Attempt to Base a Classification of the Elements on Atomic Structure, **5**, p. 57
Periodic Classification of the Elements, **6**, p. 341
A Periodic Chart of the Atoms, **6**, p. 553

The Electron in Organic Chemistry. I, **5**, p. 404
The Electron in Organic Chemistry. II, **8**, p. 1703
Atomic Models for Use in Inorganic Chemistry, **8**, p. 1845

Suggested Chemistry Club Programs

Option (1). Presentation of "A Bedtime Story for Wide-Awake Children" (J. CHEM. EDUC., **2**, p. 497).

Option (2). A discussion meeting using *The Chemistry Leaflet*, Vol. V, No. 4, and the articles from the JOURNAL OF CHEMICAL EDUCATION cited above for the selection of topics.

No. 5. THE HALOGENS (October 8, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Demonstration Apparatus for the Simultaneous Preparation of the Halogens, **2**, p. 440
Uses of Chlorine, **4**, p. 454
History of the Chlorine Industry, **4**, p. 313
Chlorine Research, **4**, p. 596
An Appar. tus for the Preparation of Chlorine, **5**, p. 1292
Isotopes of Chlorine and Mercury, **2**, p. 1173
A Demonstration with Hydrogen Chloride, **6**, p. 945
The Preparation of Iodine and Bromine Salts by the Easiest Method, **7**, p. 1131
Recovery of Iodine from Waste Iodide Solutions, **7**, p. 616
Iodine Content of Some South Carolina Products, **7**, p. 2396
Biochemistry and Geochemistry of Iodine, **7**, p. 2590
A Note on the Preparation of Hydriodic Acid, **8**, p. 541
Chemical Warfare, **5**, p. 929
By-Products of Chemical Warfare, **5**, p. 1505
Chemical Warfare, **6**, p. 2147; **7**, p. 95

Visual Aids

Slides

11 Slides on Chlorine and
9 Slides on the Halogens (*W. M. Welch Scientific Co., 1516 Orleans St., Chicago, Ill.*)

Motion Pictures

The Milwaukee Sewage Disposal Plant (2) (*Milwaukee Sewage Commission, 508 Market St., Milwaukee, Wis.*)
Peacetime Activities of the Chemical Warfare Service (2) (*U. S. Chemical Warfare Service, War Department, Washington, D. C.*)

Suggested Chemistry Club Programs

Option (1). A subject-matter meeting using *The Chemistry Leaflet*, Vol. V, No. 5, and articles from the JOURNAL OF CHEMICAL EDUCATION for the selection of topics and subject matter.

Option (2). Showing of a motion picture on a closely related subject.

Option (3). The Halogens Argue (*Chem. Leaflet*, **2**, No. 6, p. 15)

No. 6. ACIDS, BASES, SALTS (October 15, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Modern Conceptions of Acids and Bases, **7**, p. 782
A General Definition of Acids, Bases, and Salts, **5**, p. 1425

Svante Arrhenius and the Theory of Ionization, **5,** p. 1486
The Present Status of the Ionization Theory, **2,** p. 374
A Freshman Experiment? The Reaction of Magnesium with Acids, **8,** p. 1566

Suggested Chemistry Club Programs

Option (1). Any chemistry play.

Option (2). A subject matter discussion using *The Chemistry Leaflet,* Vol. V, No. 6, and articles from the JOURNAL OF CHEMICAL EDUCATION for topics and subject matter.

Option (3). An exhibit on the principal uses of the most important "heavy" chemicals, using posters or any other suitable agency. The laboratory may serve as an exhibit room if no other place is available.

No. 7. SULFUR AND ITS COMPOUNDS (October 22, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Sulfur Mining, **6,** p. 129
Sulfur—A Model for Illustrating the Frasch Method, **7,** p. 1385; **8,** p. 1630
Number of Atoms in the Sulfur Molecule, **6,** p. 556
Sulfur, A Poster, **8,** p. 696
A Chamber Sulfuric Acid Plant for Lecture Demonstration, **7,** p. 1668
Sulfuric Acid—An Experiment Illustrating the Lead-Chamber Reaction, **7,** p. 1138
Sulfuric Acid Model for Illustrating Lead-Chamber Process, **7,** p. 1387
A Miniature Contact-Process Sulfuric Acid Plant, **6,** p. 1781
Hydrogen Sulfide as a Laboratory and Industrial Poison, **4,** p. 613
An Efficient and Economical Hydrogen Sulfide Generator, **5,** p. 49
A Convenient Form of Hydrogen Sulfide Generator, **5,** p. 1428
Generation of Hydrogen Sulfide, **7,** p. 1901
A Simplified Hydrogen Sulfide Generator, **7,** p. 2172
Pioneers in the Development of Rubber, **7,** p. 1788
Latex Sprayed Rubber, **2,** p. 1176
Rubber: Newer Theoretical and Practical Developments, **8,** p. 7
Chemistry of Rubber, **3,** p. 253
Work of the Bureau of Standards on Rubber, **3,** p. 291

Visual Aids

Slides

8 Slides on Sulfur and Sulfides (*W. M. Welch Scientific Co., 1516 Orleans St., Chicago, Ill.*)
10 Slides on Rubber (*same company*)
16 Slides on Rubber (*Stillfilm, Inc., 1052 Cahuenga Avenue, Hollywood, Calif.*)
53 Slides on Rubber (*Spencer Lens Co., 19 Doat St., Buffalo, N. Y.*)
53 Slides on Rubber (*Ideal Pictures Corp., 26 East 8th St., Chicago, Ill.*)

Motion Pictures

The Story of Sulfur (2 reels, 16 and 35 mm.) (*Acme Educational Film Service, 1132–1136 W. Austin Avenue, Chicago, Ill.; Bureau of Mines, 4800 Forbes St., Pittsburgh, Penna.; Indiana University, Bloomington, Ind.; Iowa State College, Visual Instruction Service, Ames, Ia.; Rothacker Cement Association, 23 West Grand Avenue, Columbus, O.*)

"Say, Joe, Do You Know Is These Things Got Any Vitamin C in 'Em?"

A CARTOON REPRINTED BY PERMISSION FROM *Judge*, WHICH SHOWS THE EVER-INCREASING POPULAR APPRECIATION OF A SUBJECT ONCE TOO TECHNICAL FOR ANY BUT A TRAINED SCIENTIST

The effectiveness of a medicine is no longer measured in terms of its bitterness. Chemical cartoons appearing each week in *The Chemistry Leaflet* help rob chemistry of the formality which formerly cloaked it.

Experiments in Sulfur (1 reel, 35 mm.) (*Fruit of the Loom Mills, Inc., 40 Worth Street, N. Y. C.*)

Romance of Rubber (2 reels, 16 and 35 mm.) (*Rothacker Film Corporation, 113–115 W. Austin Ave., Chicago, Ill.; Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st Street, N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Conquering the June (1 reel, 16 and 35 mm.) (*Goodyear Tire Co., Akron, Ohio; International Harvester Co., 606 S. Michigan Ave., Chicago, Ill.*)

Rubber (1 reel, 16 mm.) (sale only) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)

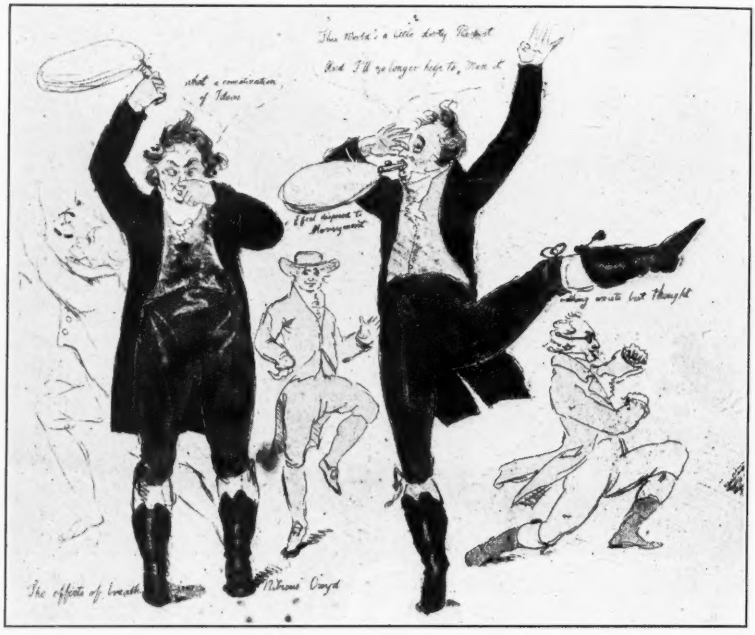
Rubber Industry (1 reel, 35 mm.) (*Indiana University, Bloomington, Ind.*)

Rubber of Yesterday (1 reel, 35 mm.) (*Acme Educational Film Service, 1132–1136 W. Austin Avenue, Chicago, Ill.*)

Story of a Tire (1 reel, 16 and 35 mm.) (*Goodyear Tire Co., Akron, Ohio*)

Story of Rubber (4 reels, 16 mm.) (*De Frenes and Company, 60 N. State St., Wilkes-Barre, Penna.*)

Where They Go Rubbering (1 reel, 35 mm.) (*Iowa State College, Visual Instruction Service, Ames, Ia.; National Cash Register Co., Main and K Sts., Dayton, O.*)



A CARTOON OF HISTORICAL INTEREST RELATING TO THE DISCOVERY OF LAUGHING GAS

Suggested Chemistry Club Programs

Option (1). A subject-matter program, using *The Chemistry Leaflet*, Vol. V, No. 7, and the suggested articles in the JOURNAL OF CHEMICAL EDUCATION for the selection of topics and as sources of subject matter.

Option (2). Presentation of one or more of the motion-picture films listed on this subject.

No. 8. NITROGEN AND ITS COMPOUNDS (October 29, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Reversing the Nitrogen Debit, **5**, p. 1464
Nitrogen: In War and Peace, **2**, p. 275
Nitrogen as a Plant Food, **3**, p. 50
The Nitrogen Problem in Agriculture, **4**, p. 845
Fixation of Atmospheric Nitrogen, **3**, p. 170
Fertilizer from Air, **8**, p. 462
Demonstration of Nitrogen Fixation, **7**, pp. 2167, 2169
The Historical Development and Theory of Ammonia Synthesis, **6**, p. 2097
Synthetic Ammonia in the Fertilizer Industry, **6**, p. 894
The Direct Synthesis of Ammonia: A Lecture Table Experiment, **2**, p. 285
Demonstration: Ammonia and Destructive Distillation, **8**, p. 932
Catalysis—A New Factor in Industry, **2**, p. 631
Synthetic Ammonia by Catalysis, **3**, p. 284
A Colored Ammonia Fountain, **8**, p. 1059

Cooling and Refrigeration, **6,** p. 1768
Blasting Explosives, **5,** p. 1213
Alfred Nobel, Inventor of Dynamite, **5,** p. 1480

Visual Aids

Slides

21 Slides on Nitrogen (*W. M. Welch Scientific Co., 1516 Orleans St., Chicago, Ill.*)
21 Slides on Ice: Natural and Artificial (*University of the State of New York, Albany, N. Y.*)
100 Slides on Ice and Refrigeration (*Society for Visual Education, Inc., 327 South LaSalle Street, Chicago, Ill.*)
10 Slides on Elements of the Nitrogen Group (*W. M. Welch Scientific Co., 1516 Orleans Street, Chicago, Ill.*)

Motion Pictures

Making Air-Nitrogen in Germany (2 reels, 35 mm.) (*Synthetic Nitrogen Products Corp., Agricultural Department, 285 Madison Ave., N. Y. C.*)
A Visit to the Nitrate Fields of Chile (1 reel, 35 mm.) (*E. I. du Pont de Nemours and Co., Wilmington, Del.*)
The Chilean Nitrate Industry (2 reels, 16 and 35 mm.) (*Chilean Nitrate of Soda Educational Bureau, 57 William St., N. Y. C.*)
Farm for Sale (1 reel, 35 mm.) (*C. L. Venard, 702 S. Adams St., Peoria, Ill.*)
Refrigeration (1 reel, 16 mm.) (sale only) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)
Silica Gel (Refrigeration) (3 reels, 16 and 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 21st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)
Dynamite, Concentrated Power (1 reel, 35 mm.) (*U. S. Department of Agriculture, Washington, D. C.*)
Explosives—Dusts (2 reels, 35 mm.) (*U. S. Department of Agriculture, Washington, D. C.*)
Hydro-Electric Power Production in the New South (2 reels, 16 and 35 mm.) (*E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.*)
Manufacture of Smokeless Powder (1 reel, 35 mm.) (*Indiana University, Bloomington, Ind.*)
Rubbing the New Aladdin's Lamp (1 reel, 35 mm.) (*Hercules Powder Co., Wilmington, Del.; Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)
The Manufacture and Use of Ammonium Sulfate (2 reels, 35 mm.) (*The Barret Co., Agricultural Dept., Medina, Ohio*)
The Modern Hercules (1 reel, 35 mm.) (*Hercules Powder Co., Wilmington, Del.; Indiana University, Bloomington, Ind.; Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Suggested Chemistry Club Programs

Option (1). Explosives: A Burlesque Lecture (J. CHEM. EDUC., **7,** p. 653)
Option (2). A presentation of one or more of the motion pictures listed above.
Option (3). A subject-matter program, using *The Chemistry Leaflet,* Vol. V, No. 8, and the selected articles from the JOURNAL OF CHEMICAL EDUCATION listed here as aids in the selection of topics and of subject matter.

No. 9. THE AIR (November 5, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Experiment on Air, **8,** p. 930
Liquid Air, **8,** p. 1027
Rare Gases of the Atmosphere, **4,** p. 1376
Some Uses for Atmospheric Gases, **5,** p. 1327
The Production of Helium, **7,** p. 2408
Helium and Natural Gas, **3,** p. 45
Neon Arc Lights, **5,** p. 1332

Visual Aids

Slides

Slides on Air: Part I, Oxygen, 57 Slides; Part II, Nitrogen and Carbon Dioxide, 60 Slides; Part III, Characteristics of the Air, 61 Slides (*Visual Text Sales Company, 1890 Crenshaw Blvd., Los Angeles, Calif.*)

Motion Pictures

Air (1 reel, 16 mm.) (rent) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

A 35 mm. picture on this subject may also be obtained from the above address, or may be secured without charge from (*Rothacker Film Corp., 113–115 W. Austin Avenue, Chicago, Ill.*)

Atmospheric Pressure (1 reel, 16 mm.) (sale only) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)

Liquid Air (1 reel, 16 and 35 mm.) (*General Electric Co., 1 River Road, Schenectady, N. Y.; also University of Wisconsin, Madison, Wis.*)

Story of Compressed Air (2 reels, 35 mm.) (*Y. M. C. A., Motion Picture Bureau, 1111 Center St., Chicago, Ill.*)

Suggested Chemistry Club Programs

Option (1). A lecture-demonstration on the properties of liquid air.

Option (2). A showing of one or more of the suggested movies on air.

Option (3). A program on the uses of neon, helium, and others of the so-called rare gases of the atmosphere.

No. 10. THE WORLD'S FOOD SUPPLY (November 12, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Nutrition Problems of the South, **7,** p. 2336
Chemical Problems of the Cane Sugar and Molasses Industry, **7,** p. 2326
Xylose, **7,** p. 2403
Story of a Grain of Corn, **4,** pp. 574, 758, 861
From Corn to Karo—A Student Project, **7,** p. 1147
Know Your Foods—Oleomargarine, **5,** p. 1621
Know Your Foods—Graham Bread, **6,** p. 59
Know Your Foods—Canned Foods, **6,** p. 314
The Banana—A Challenge, **7,** p. 1537
Rôle of Mineral Salts in Animal Life, **4,** p. 1269
Carotin and Vitamin A, **8,** p. 875
The Vitamins, **3,** p. 1240, 1416; **4,** pp. 66, 214, 323, 474
Preparation and Chemistry of Insulin, **3,** p. 134

Enzymes and Vitamins in Present-Day Chemistry, **8,** p. 652
Hormones, **8,** p. 661
Peanut Industry, **7,** pp. 794, 1037, 1277, 1617, 1859
A Novel High-School Experiment in Hydrogenation of Oils, **8,** p. 1856.

Visual Aids

Slides

47 Slides on Some By-Products of the Meat Packing Industry (*Ideal Pictures Corp., 26 East 5th St., Chicago, Ill.*)
45 Slides on Production of Clean Milk (*U. S. Department of Agriculture, Washington, D. C.*)
23 Slides on Flour Milling (*Spencer Lens Co., 19 Doat St., Buffalo, N. Y.*)
13 Slides on Sugar and Glucose (*W. M. Welch Scientific Co., 1516 Orleans St., Chicago, Ill.*)

Motion Pictures

Inside Out (Story of Digestion in Animated Drawings) (1 reel, 35 mm.) (*Y. M. C. A., Motion Picture Bureau, 1111 Center St., Chicago, Ill.*)
A B C of Food (1 reel, 35 mm.) (rent only) (*Edited Pictures Systems, Inc., 130 W. 46th St., N. Y. C.*)
Across Seven Seas (Tapioca) (1 reel, 16 and 35 mm.) (*J. Alexander Leggett Co., 2 W. 46th St., N. Y. C.*)
Better Bread (1 reel, 16 and 35 mm.) (*American Dry Milk Institute, Chicago, Ill.*)
Better Milk (1 reel, 16 and 35 mm.) (rent only) (*Edited Pictures System, Inc., 130 W. 46th St., N. Y. C.*)
Chemical Composition and Food Value of Whole Wheat (3 reels, 35 mm.) (*Rowland Rogers Productions, 74 Sherman St., at Harris Avenue, Long Island, N. Y.*)
Corn (1 reel, 16 mm.) (sale only) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)
Crystals of Commerce (1 reel, 16 and 35 mm.) (*Rothacker Film Corp., 113–115 W. Austin Avenue, Chicago, Ill.*)
Familiar Foods from Foreign Lands (1 reel, 35 mm.) (rent) (*Film Classic Exchange, 265 Franklin St., Buffalo, N. Y.*)
Filling the World's Cereal Bowl (2 reels, 35 mm.) (*Rothacker Film Corp., 113–115 W. Austin Ave., Chicago, Ill.*)
Food (1 reel, 35 mm.) (rent) (*Carter Cinema Producing Corp., 551 Fifth Avenue, N. Y. C.;* (also rent) *Edited Pictures Exchange, 130 W. 46th St., N. Y. C.*)
Home Builders (3 reels, 35 mm.) (*International Harvester Co., 6 6 S. Michigan Avenue, Chicago, Ill.; Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.; Chicago Film Laboratory, Inc., 666 Lake Shore Drive, Chicago, Ill.*)
Keeping Out Bad Food (1 reel, 35 mm.) (*National Cash Register Co., Main and K Sts., Dayton, Ohio; U. S. Department of Agriculture, Washington, D. C.*)
Land of Cherries (1 reel, 35 mm.) (*Indiana University, Bloomington, Ind.; International Harvester Co., 6 6 S. Michigan Ave., Chicago, Ill.; Iowa State College, Visual Instruction Service, Ames, Ia.; Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C.; 300 W. Adams Bldg., Chicago, Ill.; University of Wisconsin, Madison, Wis.; Chicago Film Laboratory, Inc., 666 Lake Shore Drive, Chicago, Ill.*)
Leavener of Life (1 reel, 35 mm.) (*Rothacker Film Corp., 113–115 W. Austin Avenue, Chicago, Ill.*)
Leavening (3 reels, 35 mm.) (*Indiana University, Bloomington, Ind.*)

Making Malted Milk (1 reel, 35 mm.) (*University of Wisconsin, Madison, Wis.*)

Making Maple Sugar (1 reel, 16 and 35 mm.) (rent) (*Edited Pictures System, Inc., 130 W. 46th St., N. Y. C.*)

Meat Packing (1 reel, 16 mm.) (sale) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)

Once Over and It's All Over (2 reels, 35 mm.) (*International Harvester Co., 606 S. Michigan Ave., Chicago, Ill.; Chicago Film Laboratory, Inc., 666 Lake Shore Drive, Chicago, Ill.*)

Peanuts (1 reel, 16 mm.) (sale only) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)

Power Behind the Orange (1 reel, 35 mm.) (*International Harvester Co., 606 S. Michigan Ave., Chicago, Ill.; Indiana University, Bloomington, Ind.; Iowa State College, Visual Instruction Service, Ames, Ia.; Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.; University of Wisconsin, Madison, Wis.; Chicago Film Laboratory, Inc., 666 Lake Shore Drive, Chicago, Ill.*)

Sunshine (1 or 2 reels, 16 or 35 mm.) (*Rothacker Film Corp., 113–115 W. Austin Avenue, Chicago, Ill.*)

Sugar Trail Beets (1 reel, 35 mm.) (*American Sugar Refining Co., 117 Wall Street, N. Y. C.*)

Sunshine from the Sea (3 reels, 35 mm.) (*E. R. Squibb and Sons, Pharmaceutical Division, 80 Beekman St., N. Y. C.*)

Suggested Chemistry Club Programs

Option (*1*). A subject-matter program on the topic, A Six-Sided Meal, in which the functions of the necessary types of foods and some of the modern nutritional problems are discussed.

Option (*2*). A presentation of one or more of the suggested motion pictures on foods.

Option (*3*). A chemical banquet in which a meal is prepared in the laboratory and served in beakers and evaporating dishes. See *The Chemistry Leaflet*, Vol. IV, No. 34, p. 20.

Option (*4*). A combination of various parts of the first three options.

No. 11. PHOSPHORUS AND ITS RELATIVES (November 19, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

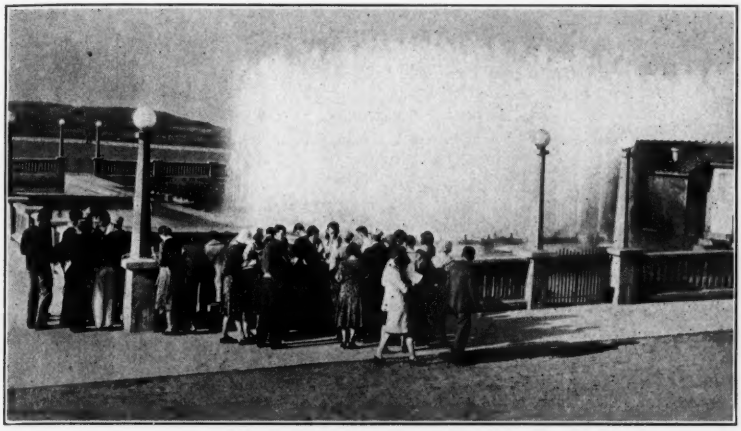
Kunkel and the Early History of Phosphorus, **4,** p. 1105
World Conditions as to Chemical Plant Foods, **7,** p. 2634
Concentrated Fertilizers, **6,** p. 899
Problems in the Fertilizer Industry, **7,** p. 2330
A Qualitative Test for Arsenic or Antimony, **5,** p. 24
Insects and Chemistry, **6,** p. 1100
Problems in the Production and Use of Insecticides in the South, **7,** p. 2301
Fusible Alloys, **8,** p. 931

Visual Aids

Slides

50–60 Slides on A Fertile Soil Means a Prosperous People (*International Harvester Co., 606 S. Michigan Ave., Chicago, Ill.*)

12 Slides descriptive of Grinnell Sprinklers (*Grinnell Co., Inc., 277 W. Exchange St., Providence, R. I.*)



INSPECTION TRIPS HAVE A SPECIAL APPEAL TO STUDENTS. IF CAREFULLY PLANNED THEY HAVE EXCEPTIONAL EDUCATIONAL VALUE

The members of the Chemistry Club of South High School, Denver, pay a visit to the municipal waterworks.

Motion Pictures

The Grinnell Sprinkler Head (1 reel, 35 mm.) (*Grinnell Co., Inc., 277 W. Exchange St., Providence, R. I.*)

Story of a Lucifer Match (1 reel, 35 mm.) (rent) (*Edited Pictures System, Inc., 130 W. 46th St., N. Y. C.; Pictorial Clubs, Inc., 808 S. Wabash St., Chicago, Ill.*)

Suggested Chemistry Club Programs

Option (*1*). A historical meeting, in which the early story of phosphorus is told either by using extracts from the article on Kunkel and the Early History of Phosphorus listed above, or by preparing a one-act play based upon the facts set forth in this article. Some member of the club with particular talents in this direction could easily write a playlet on this fascinating subject.

Option (*2*). A demonstration program, in which home-made matches, a miniature automatic sprinkler system using a bismuth fusible alloy, and other things pertaining to the wide variety of interesting applications of phosphorus, arsenic, antimony, and bismuth might be shown.

Option (*3*). A presentation of one or more motion pictures on related subjects.

No. 12. CARBON AND ITS INORGANIC COMPOUNDS (November 26, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Carbon—Poster, **8,** p. 690
Graphite in the United States, **6,** p. 517
Dust Explosions, **3,** p. 1008
A New Method of Illustrating Dust Explosions, **5,** p. 349
Gas Masks, **7,** p. 294
Decolorizing Action of Carbon, **7,** p. 1299

Printing Ink, **3,** p. 408
The Sulfides of Carbon, **8,** p. 867
Carbon Dioxide in Modern Life, **5,** p. 1321
Carbon Dioxide—Its Relation to Life, **7,** p. 151
Carbon Dioxide—Its Industrial Application, **7,** p. 403
Carbon Dioxide—Its Commercial Manufacture, **7,** p. 637
The Other Oxides of Carbon, **8,** p. 232
Chemistry in the Development of the Gas Industry, **5,** p. 291
Gas Lighting—Life and Chemical Services of Frederick Accum, **2,** pp. 829, 1008, 1140
Development of the Gas Industry, **6,** p. 738
Robert Wilhelm Bunsen, **4,** p. 431
Cork and Its Uses, **8,** p. 1463

Visual Aids

Slides

28 Slides on Carbon (*W. M. Welch Scientific Co., 1516 Orleans St., Chicago, Ill.*)

Motion Pictures

Acres of Diamonds (1 reel, 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 Adams Bldg., Chicago, Ill.*)

A Rush for Diamonds (1 reel, 16 or 35 mm.) (*Ufa Films, Inc., 1540 Broadway, N. Y. C.*)

Behind the Pyramids (3 reels, 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Buried Sunshine (2 reels, 16 or 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Burning Questions (2 reels, 16 and 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Carbon Monoxide, The Unseen Danger (1 reel, 16 and 35 mm.) (*Bureau of Mines, 4800 Forbes St., Pittsburgh, Penna.; also Iowa State College, Visual Instruction Service, Ames, Ia.*)

Coal Mining (Surface) (1 reel, 35 mm.) (rent) (*University of Wisconsin, Madison, Wis.*)

How a Lead Pencil Is Made (1 reel, 35 mm.) (*J. Alexander Leggett Co., 2 West 46th St., N. Y. C.*)

Industrious Diamonds (1 reel, 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Dust Explosions (1 reel, 35 mm.) (*U. S. Department of Agriculture, Motion Picture Laboratories, 1363 C Street, N. W., Washington, D. C.*)

Suggested Chemistry Club Programs

Option (1). Playlet—A Janitor's Life (J. CHEM. EDUC., **6,** p. 1793).

Option (2). A demonstration program in such subjects as Dry Ice—Its Manufacture and Uses; Carbon Dioxide as a Fire Extinguishing Material; Uses of the Allotropic Forms of Carbon; and Principles of the Gas Mask.

Option (3). Showing of motion pictures on related subjects.

No. 13. CARBON AND ITS ORGANIC COMPOUNDS (December 3, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Thomas Paine's Theory of Atmospheric Contagion and His Account of an Experiment Performed by George Washington upon the Production of Marsh Gas, **2**, p. 99

Synthetic Methanol, **2**, p. 429

Uses of Ethylene, **2**, p. 459

Faraday's Discovery of Benzene, **3**, p. 1248

August Kekulé, **4**, p. 697

The Relation of Chemistry to the Development of a Natural Resource—Coal, **6**, p. 1709

Model By-Product Coke Plant, **6**, p. 745

A Practical Apparatus for the Destructive Distillation of Coal and Wood, **6**, p. 1761

Coal, Distillation of—A Demonstration, **8**, p. 150

Visual Aids

Slides

51 Slides on Anthracite Coal; 52 Slides on Bituminous Coal; 103 Slides on Part I and 74 Slides on Part II of the Story of Coal; and 98 Slides on Petroleum and Gas (*Ideal Pictures Corporation, 26 East 8th St., Chicago, Ill.*)

18 Slides on the Chemistry and Constitution of Coal; 120 Slides on Anthracite Coal Mining; and 44 Slides giving a shorter version of the previous set (*U. S. Bureau of Mines, Experiment Station, Pittsburgh, Penna.*)

42 Slides on Coal Mining (*University of the State of New York, Albany, N. Y.*)

51 Slides on Anthracite Coal, and 52 slides on Bituminous Coal (*Spencer Lens Co., 19 Doat St., Buffalo, N. Y.*)

Motion Pictures

Chemical Ethyl Alcohol (2 reels, 16 and 35 mm.) (*De Frenes and Co., 69 N. State St., Wilkes-Barre, Penna.; Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Anthracite Coal (1 reel, 16 mm.) (sale) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)

Bituminous Coal (1 reel, 16 mm.) (sale) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)

Fertilizer from Coal (3 reels, 35 mm.) (*Rothacker Film Corp., 113–115 W. Austin Ave., Chicago, Ill.*)

Doings of Terp and Tine (1 or 2 reels, 35 mm.) (*Hercules Powder Co., Wilmington, Del.; Iowa State College, Visual Instruction Service, Ames, Ia.; Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Oil, The Wood Preserver (1 reel, 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Oil Tydings (4 reels, 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Story of a Rotary Drilled Oil Well (2 reels, 35 mm.) (*Bureau of Mines, 4800 Forbes St., Pittsburgh, Penna.*)

Story of Gasoline (3 reels, 35 mm.) (*Acme Educational Film Service, 1132–1136 W. Austin Ave., Chicago, Ill.; Bureau of Mines, 4800 Forbes St., Pittsburgh, Penna.; Indiana University, Bloomington, Ind.*)

Story of Lubricating Oil (2 reels, 35 mm.) (*Bureau of Mines, 4800 Forbes St., Pittsburgh, Penna.*)

Story of Lubrication (1 reel, 35 mm.) (*Bureau of Mines, 4800 Forbes St., Pittsburgh, Penna.*)

Story of Natural Gas (4 reels, 35 mm.) (*Acme Educational Film Service, 1132–1136 W. Austin Ave., Chicago, Ill.*)

Story of Petroleum (4 or 7 reels, 35 mm.) (*Acme Educational Film Service, 1132–1136 W. Austin Ave., Chicago, Ill.; Indiana University, Bloomington, Ind.*)

Story of Petroleum (8 reels, 35 mm.) (*Bureau of Mines, 4800 Forbes St., Pittsburgh, Penna.*)

Story of Turpentine (1 reel, 35 mm.) (*Indiana University, Bloomington, Ind.*)

Through Oil Fields of Mexico (3 reels, 16 and 35 mm.) (*Bureau of Mines, 4800 Forbes St., Pittsburgh, Penna.*)

World Struggle for Oil (7 reels, 35 mm.) (*Acme Educational Film Service, 1132–1136 W. Austin Ave., Chicago, Ill.; Indiana University, Bloomington, Ind.*)

Suggested Chemistry Club Programs

Option (1). A "Coal-Tar" program, in which posters, exhibits, and slides are used to show the everyday products derived from this source.

Option (2). Presentation of motion pictures on related subjects.

Option (3). A subject-matter meeting in which *The Chemistry Leaflet*, Vol. V, No. 13 (Dec. 3, 1931) and various articles from the JOURNAL OF CHEMICAL EDUCATION serve as aids in the selection of topics and of subject matter.

Option (4). A "Petroleum" program in which the everyday importance of petroleum derivatives serve as the topic.

No. 14. SYNTHETIC CHEMISTRY (December 10, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

How New Chemical Products Are Invented, **6**, p. 2178

Recent Progress in the Field of Synthetic Perfumes, **8**, p. 1311

The Future of the Synthetic Organic Chemical Industry in America, **2**, p. 519

Automobile Lacquer, **2**, p. 369

Duco and Other Synthetic Products, **2**, p. 1161

The Story of Paper, **7**, p. 1739

The Paper Industry in the South, **7**, p. 2360

Southern Pine, **7**, p. 2291

Utilization of Bagasse in the Manufacture of Celotex, **7**, p. 2391

Manufacture of Insulation Board and Presdwood by the Masonite Process, **7**, p. 2387

The Natural Chemical Resources of Australia Plant Products, **6**, p. 1195

Future Possibilities in the Utilization of Cellulose, **6**, p. 829

Utilization of Agricultural Wastes, **7**, p. 1563

Preparation of a Synthetic Resin, **7**, p. 1663

Bakelite, **2**, p. 1153

Nature Was Notably Aided, **6**, p. 607

Karolith—The American Casein Plastic, **2**, p. 1171

The Outlook for Synthetic Rubber, **6**, p. 1286

Visual Aids

Slides

110 Slides on the Manufacture of Paper and 37 slides on Paper (*Ideal Pictures Corp., 26 East 8th St., Chicago, Ill.*)

Motion Pictures

A Day with the Sun (2 reels, 16 and 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Forest to Newsboy (1 reel, 35 mm.) (*National Cash Register Co., Main and K Sts. Dayton, Ohio.*)

Paper Making (1 reel, 35 mm.) (*Indiana University, Bloomington, Ind.*)

The Voice of Business (3 reels, 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Wall Paper the Beautiful (2 reels, 16 and 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

World of Paper (2 reels, 35 mm.) (*General Electric Co., 1 River Road, Schenectady, N. Y.; Indiana University, Bloomington, Ind.*)

Story of Bakelite (2 reels, 35 mm.) (*Indiana University, Bloomington, Ind.; Rothacker Film Corp., 113–115 W. Austin Avenue, Chicago, Ill.; Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Suggested Chemistry Club Programs

Option (1). A display of synthetic products, such as bakelite, karolite, toilet sets made of cellulose plastics, articles painted with cellulose lacquers, artificial "pearl" beads, and synthetic textile fabrics and dyes.

Option (2). Presentation of motion pictures on related subjects.

No. 15. THE WORLD'S CLOTHING SUPPLY (December 17, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Chemical Problems in Connection with the Cotton Textile Industry, **7,** p. 2307
Relation of Cotton to Chemistry, **7,** pp. 1802–49
Relation of Chemistry to the Development of the Cotton Industry, **4,** p. 743
Textiles from Test Tubes, **6,** pp. 141, 357, 541, 753
Rayon—Today and Tomorrow, **7,** p. 2543
The Rayon Industry in the South, **7,** p. 2354
A Laboratory Reproduction of the Viscose Process, **8,** p. 1171
Rayon—Man-Made Silk, **2,** p. 864
Viscose Rayon, **4,** p. 1260
Dye Industry in America, **3,** p. 1128
Growth of the Dyestuffs Industry, **3,** p. 973
Discovery of Synthetic Alizarin, **7,** p. 2609
An Outline of the Dye Industry, **3,** p. 1259

Visual Aids

Slides

103 Slides on the Story of Silk; 20 slides on Silk—Japan; and 26 slides on Silk—United States (*Ideal Pictures Corp., 26 East 8th St., Chicago, Ill.*)

62 Slides on From Cocoon to Spool (*The Corticelli Silk Co., 136 Madison Avenue, N. Y. C.*)

36 Slides on Cotton Production; 30 slides on Cotton Manufacture; 48 slides on Flax and Linen; 21 slides on Wood Production, and 33 slides on Wool Manufacture (*Spencer Lens Co., 10 Doat St., Buffalo, N. Y.*)

Motion Pictures

Civilizations Fabric (Cotton) (2 reels, 16 and 35 mm.) (*Fruit of the Loom Mills, Inc., 40 Worth St., N. Y. C.*)

Cotton Growing (1 reel, 16 mm.) (sale) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)

Cotton Goods (1 reel, 16 mm.) (sale) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)

From Cocoon to Spool (1 reel, 16 mm.) (*The Corticelli Silk Co., 136 Madison Avenue, N. Y. C.*)

(35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.; The Corticelli Silk Co., 136 Madison Ave., N. Y. C.*)

From Flax to Linens (1 reel, 16 mm.) (sale) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)

Golden Fleece (1 reel, 16 and 35 mm.) (*Ufa Films, Inc., 1540 Broadway, N. Y. C.*)

Making of Twine (1 reel, 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

The Romance of Rayon (2 reels, 35 mm.) (*The Viscose Company, 171 Madison Avenue, N. Y. C.*)

Suggested Chemistry Club Programs

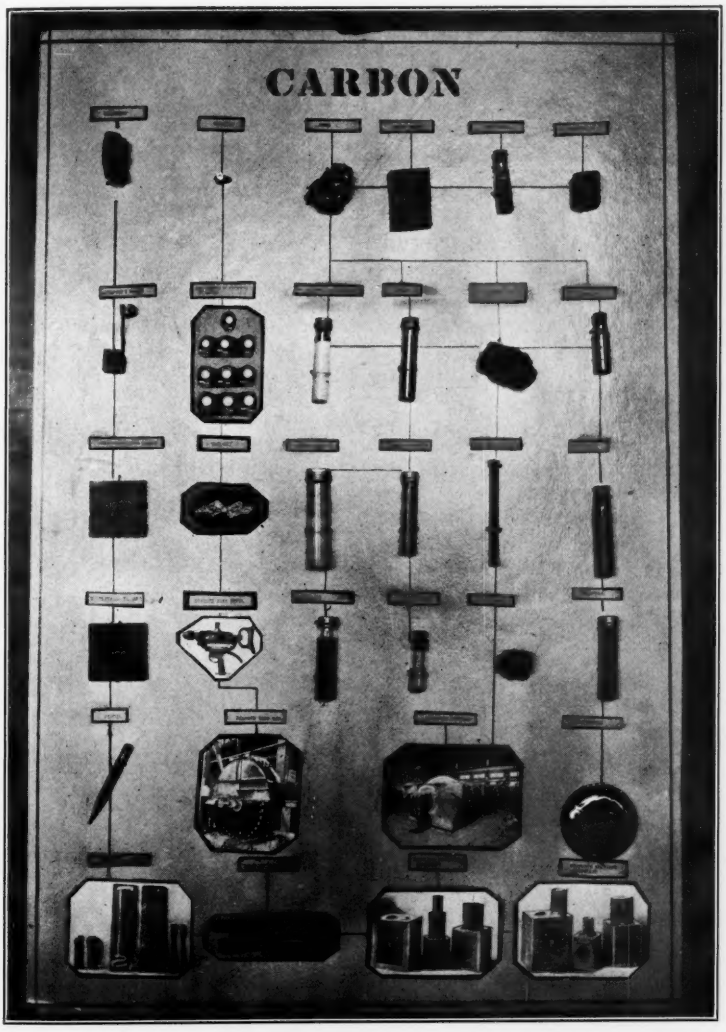
Option (1). A demonstration of methods of testing for the presence of the various common textile fibers, accompanied by discussion as to the production and characteristics of the fibers.

Option (2). A program on the production of synthetic fibers, in which the film The Romance of Rayon is shown, and samples of representative fabrics made of synthetic textile fibers are displayed.

No. 16. SILICON, BORON, AND THEIR COMPOUNDS (December 31, 1931)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Silicon—Poster, **8,** p. 694
Life Layer of the World, **7,** p. 1993
Diatomaceous Earth, **7,** p. 2829
Glass, Its Composition and Properties, **8,** p. 421
Optical Glass, **2,** p. 1155
Bernard Palissy, **8,** p. 1045
Chinese Pottery, **8,** p. 1249
Pyrex, **2,** p. 1158
The Story of Portland Cement, **6,** pp. 1855, 2128
Portland Cement Research, **3,** p. 519
Dental Cements, **6,** pp. 311, 312
Boron: Its Importance in Plant Growth, **5,** p. 1235
New Borate Mineral Finding Commercial Use, **7,** p. 2173



A POSTER BY A STUDENT AT NOKOMIS TOWNSHIP HIGH SCHOOL, NOKOMIS, ILLINOIS

A poster exhibit may be held by the Student Chemistry Club. The making of posters by club members will help to correlate the work of the club with that of the classroom.

Visual Aids

Slides

23 Slides on Brick; 50 slides in one set and 103 in another on Building Stone; 40 slides on Glass; 22 slides on Concrete; 25 slides on Pottery; and 33 slides on Tile (*Ideal Pictures Corp., 26 East 8th St., Chicago, Ill.*)

50 Slides on the Manufacture of Portland Cement (*Portland Cement Association, 33 West Grand Avenue, Chicago, Ill.*)

13 Slides on Silicon and Boron; 5 slides on Glass; and 4 slides on Brick (*W. M. Welch Scientific Co., 1516 Orleans St., Chicago, Ill.*)

Motion Pictures

Age of Speed (4 reels, 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Jewels of Industry (2 reels, 16 mm.) (*Rothacker Film Corp., 113–115 W. Austin Avenue, Chicago, Ill.*)

(35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Asbestos for 1000 Years (1 reel, 35 mm.) (*Ideal Pictures Corp., 26 E. 8th St., Chicago, Ill.*)

Story of Asbestos (1 reel, 16 and 35 mm.) (*Bureau of Mines, 4800 Forbes St., Pittsburgh, Penna.*)

Cementing the Centuries (2 reels, 35 mm.) (*Indiana University, Bloomington, Ind.; Iowa State College, Visual Instruction Service, Ames, Ia.; Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Story of Portland Cement (1 reel, 16 and 35 mm.) (*De Frenes and Co., 60 N. State St., Wilkes-Barre, Penna.; Indiana University, Bloomington, Ind.; Portland Cement Association, 33 W. Grand Ave., Chicago, Ill.; Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.; Chicago Film Laboratory, Inc., 666 Lake Shore Drive, Chicago, Ill.*)

Craftsmanship of Stucco Texture (1 reel, 35 mm.) (*Chicago Film Laboratory, Inc., 666 Lake Shore Drive, Chicago, Ill.*)

Fire-Clay Refractories (3 reels, 16 and 35 mm.) (*Bureau of Mines, 4800 Forbes St., Pittsburgh, Penna.*)

From Clay to Pavement (1 reel, 35 mm.) (*Acme Educational Film Service, 1132–1136 W. Austin Avenue, Chicago, Ill.; U. S. Department of Agriculture, Washington, D. C.*)

Making Lenox Pottery (1 reel, 35 mm.) (*Iowa State College, Visual Instruction Service, Ames, Ia.; Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill. This film can also be rented from H. O. Davis, 166 Hudson St., Oklahoma City, Okla.*)

Making Pottery (1 reel, 35 mm.) (*H. O. Davis, 160 S. Hudson St., Oklahoma City, Okla.*)

Manufacture and Use of Face Brick (1 reel, 16 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*

(35 mm.) (*may be secured from the above company or from Chicago Film Laboratory, Inc., 666 Lake Shore Drive, Chicago, Ill.*)

Pottery (1 reel, 35 mm.) (*Indiana University, Bloomington, Ind.*)

Romance of Clay (1 reel, 35 mm.) (*Clay Products Association, Chicago, Ill.*)

Terra Cotta (1 reel, 16 and 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

The Potter's Wheel (1 reel, 16 and 35 mm.) (*General Electric Co., 1 River Road, Schenectady, N. Y.*)

Glass Blowing (2 reels, 16 mm.) (sale) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)

Romance of Glass (1 reel, 16 mm.) (*The Ball Brothers, Muncie, Ind.*)
(35 mm.) (*Indiana University, Bloomington, Ind.; Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.; University of Wisconsin, Madison, Wis.; The Ball Brothers, Muncie, Ind.*)

Sand and Clay (1 reel, 16 mm.) (sale) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)

Suggested Chemistry Club Programs

Option (1). A program in which a large number of products made from compounds of silicon—glass, pottery, tiles, abrasives, cement, and asbestos, for example—are displayed. Explanations of the displays should be given by members of the club.

Option (2). A program on pottery, with a showing of various kinds of pottery and porcelain.

Option (3). Presentation of one or more of the many motion pictures on products coming under this subject.

No. 17. HOW THE WORLD IS HOUSED (January 7, 1932)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Materials of Construction, **3**, p. 59. (*The Chemistry Leaflet*, Vol. 3, No. 18, and Vol. 4, No. 17, were devoted to a consideration of this subject.)

Suggested Chemistry Club Programs

Option (1). A visit to new houses, apartments, or office buildings in which some of the more recent materials of construction have been utilized.

Option (2). Discussion of the newer materials of construction, with a showing of some of those which it is possible to assemble.

No. 18. SOME OF THE UNFAMILIAR NON-METALS (January 14, 1932)

(This is a review of the non-metals with particular emphasis on those which are little known.)

No. 19. COLLOID CHEMISTRY (January 21, 1932)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

How Many Colloids Have You Used Today? **3**, p. 438
Colloids in Industry, **3**, p. 324
Application of Colloidal Chemistry to Foods, **3**, p. 1282
Application of Colloidal Chemistry to Lubrication, **3**, p. 909
Demonstration on Colloids, **8**, p. 933
Experiments with Oil in Water, **8**, p. 850
A Dance of Carbon Particles, **7**, p. 1400
Structure in Amorphous and Colloidal Matter, **6**, p. 2115

Suggested Chemistry Club Programs

Option (1). Talk on "Colloids" by an invited speaker.

Option (2). Subject-matter program in which *The Chemistry Leaflet*, Vol. V, No. 19, and the suggested articles from the JOURNAL OF CHEMICAL EDUCATION serve as helps in the selection of topics and subject matter.

No. 20. SODIUM AND ITS RELATIVES (January 28, 1932)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Sodium Now Cheap as Iron, **8,** p. 372
The Beginnings of Electrochemical Activities, **7,** p. 33
Sir Humphry Davy, **5,** p. 1664
A Method for Showing the Metallic Luster of the Alkali Metals, **6,** p. 1765
A Cheap Laboratory Sodium Press, **4,** p. 918
Method for Determining the Hydrogen Equivalent of Sodium, **7,** p. 2165
The Solvay Process—A Demonstration, **6,** p. 1763
Story of Baking Powder, *3,* p. 492
The Modern Soap Industry, **2,** pp. 1035, 1130
Potash, **4,** p. 230
Potash in the United States, **7,** p. 737
Historical Notes upon the Domestic Potash Industry in Early Colonial and Later Times, **3,** p. 749
Metallurgical Division of Bureau of Standards, **3,** p. 148
The Institute of Metals, **7,** p. 2088

Visual Aids

Slides

83 Slides on the Story of Salt (*Ideal Pictures Corp., 26 E. 8th St., Chicago, Ill.*)
24 Slides on Salt (*University of the State of New York, Albany, N. Y.*)
8 Slides on Sodium and Potassium; and 7 slides on Soap (*W. M. Welch Scientific Co., 1516 Orleans St., Chicago, Ill.*)

Motion Pictures

Common Salt (1 reel, 16 mm.) (sale) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)
Crossing the Great Salt Desert (1 reel, 35 mm.) (*University of Wisconsin, Madison, Wis.*)
Ocean Tears (1 reel, 35 mm.) (*National Cash Register Co., Main and K Streets, Dayton, Ohio*)
Pillars of Salt (1 reel, 16 mm.) (*General Electric Co., 1 River Road, Schenectady, N. Y.*)
(35 mm.) (*Indiana University, Bloomington, Ind.*)
Salt Mining (1 reel, 35 mm.) (*American Steel and Wire Co., 208 South LaSalle St., Chicago, Ill.*)
Extraction of Potassium Salts from Searles Lake (2 reels, 35 mm.) (*American Chemical and Potash Corp., 233 Broadway, N. Y. C.*)

Suggested Chemistry Club Programs

Option (1). Presentation of one or more of the motion pictures on related subjects.

Option (2). Talk on "Television" by an invited speaker.

Option (3). Exhibit meeting in which sodium, potassium, lithium, caesium, rubidium, and their compounds feature in so far as they have every-day uses.

No. 21. CALCIUM AND ITS RELATIVES (February 4, 1932)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Gypsum and Gypsum Products, **7,** p. 2788
Model Water Softener, **8,** p. 1364
Calcium Chloride for Snow Removal, **7,** p. 441

Visual Aids

Slides

29 Slides on Marble and 86 slides on The Story of Marble (*Ideal Pictures Corp., 26 East 8th St., Chicago, Ill.*)
48 Slides on Lime and Limestone (*U. S. Department of Agriculture, Washington, D. C.*)
17 Slides on Calcium (*W. M. Welch Scientific Co., 1516 Orleans St., Chicago, Ill.*)

Motion Pictures

Enamelware (2 reels, 16 and 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.; J. Alexander Leggett Co., 2 West 46th St., N. Y. C.*)
From Mine to Wall (2 reels, 35 mm.) (*International Harvester Co., 606 S. Michigan Avenue, Chicago, Ill.*)
Limestone to Marble (1 reel, 16 mm.) (sale) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)
Ten Years of Limestone (1 reel, 35 mm.) (*C. L. Venard, 702 S. Adams St., Peoria, Ill.*)

Suggested Chemistry Club Programs

Option (1). Demonstration meeting, in which methods of softening water, melting snow with calcium chloride, laying dust with calcium chloride, and use of barium and strontium salts in fireworks, are shown.

Option (2). Presentation of one of the motion pictures on related subjects.

No. 22. RADIUM AND ITS RELATIVES (February 11, 1932)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Radium, **3,** p. 623
Commercial Production and Uses of Radium, **3,** p. 757
A Lecture Experiment in Radioactivity, **5,** p. 598
Refining of Mesothorium, **8,** p. 1267
The Cathode-Ray Tube, **3,** p. 1369
Where Chemical Analyses Fail (Use of Cathode Ray Tube in Differentiating Synthetic from Artificial Gems), **7,** p. 399

Suggested Chemistry Club Programs

Option (1). A study of the life and works of Madame Curie, together with reports on the uses of radium and its relatives.

Option (2). A talk by a physician on the therapeutic value of radium.

No. 23. PRECIOUS METALS (February 18, 1932)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

The Platinum Metals, **5,** p. 1371
Gold in the Restoration of Teeth, **6,** p. 309
Silver—Poster, **8,** p. 695

Silver-Tin Amalgam in Restoring Teeth, **6,** p. 310
Chemistry of Photography, **4,** pp. 298, 465, 749

Visual Aids

Slides

30 Slides on Gold (*Ideal Pictures Corp., 26 E. 8th St., Chicago, Ill.*)
9 Slides on Silver and Gold (*W. M. Welch Scientific Co., 1516 Orleans St., Chicago, Ill.*)

Motion Pictures

Acres of Diamonds and Miles of Gold ($^1/_2$ reel, 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)
Dredge Gold Mining (1 reel, 35 mm.) (*Acme Educational Film Service, 1132–1136 W. Austin Avenue, Chicago, Ill.*)
Art of Silversmith (1 reel, 16 and 35 mm.) (*Bureau of Mines, 4800 Forbes St., Pittsburgh, Penna.*)
I See You Calling Me (1 reel, 35 mm.) (*American Telephone and Telegraph Co., 195 Broadway, N. Y. C.*)
Pictures by Wire (1 reel, 35 mm.) (*American Telephone and Telegraph Co., 195 Broadway, N. Y. C.*)
Silver (1 reel, 16 mm.) (sale) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)
Silver: Heirlooms of Tomorrow (3 reels, 16 and 35 mm.) (*Bureau of Mines, 4800 Forbes St., Pittsburgh, Penna.*)
Silverware (plating) (1 reel, 35 mm.) (*National Cash Register Co., Main and K Sts., Dayton, Ohio*)
A Trip through Filmland (*Eastman Kodak Co., Kodak Park Works, Rochester, N. Y.*)

Suggested Chemistry Club Programs

Option (1). A visit to a mint, or to a museum where precious metals and their ores are on exhibit or to a manufacturing plant in which silver plating is done.

Option (2). A talk by a dentist on the use of precious metals in the restoration of teeth.

Option (3). Presentation of one or more motion pictures on related subjects.

Option (4). A subject-matter meeting in which *The Chemistry Leaflet,* Vol. V, No. 23, and the articles suggested for reference in the JOURNAL OF CHEMICAL EDUCATION serve as helps.

No. 24. COPPER AND ITS ALLOYS (February 25, 1932)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Copper—Poster, **8,** p. 691
The Story of Copper, **6,** p. 413
Leaching Copper from Its Ores, **8,** p. 829
Copper Sulfate Solves the Central Problem of Soil Fertility in the Florida Everglades, **7,** p. 2399
Chemistry Applied to the Flotation of Ores, **5,** p. 1084
Chemistry in Mining, **8,** p. 1523

Visual Aids

Slides

89 Slides on the Story of Copper (*Ideal Pictures Corp., 26 E. 8th St., Chicago, Ill.*)
6 Slides on Copper (*W. M. Welch Scientific Co., 1516 Orleans St., Chicago, Ill.*)

Motion Pictures

Chemical Effects of Electricity (1 reel, 16 mm.) (sale) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)

Copper Mining and Smelting (1 reel, 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

From Mine to Consumer (2 reels, 16 and 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Long Drawn Out (Wire) (1 reel, 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Mining and Smelting of Copper (1 reel, 16 mm.) (sale) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)

Refining and Manufacturing of Copper (2 reels, 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Suggested Chemistry Club Programs

Option (1). A visit to a mine, or to some manufacturing establishment in which copper or its alloys are utilized.

Option (2). Presentation of a motion picture on copper.

Option (3). An exhibit meeting in which the uses of copper and its alloys are shown.

No. 25. ZINC AND ITS RELATIVES (March 3, 1932)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Zinc—Poster, **8,** p. 698
Relation of Chemistry to the Zinc Industry, **6,** p. 1455
The Oxidation of Zinc—A Demonstration, **6,** p. 976
Magnesium Starvation Found to Cause Death, **8,** p. 1223
Mercury and Its Compounds in Ancient Times, **5,** p. 419

Visual Aids

Slides

3 Slides on Magnesium, Zinc, and Mercury (*W. M. Welch Scientific Co., 1516 Orleans St., Chicago, Ill.*)

Motion Pictures

Story of Zinc Mining (1 reel, 35 mm.) (*Acme Educational Film Service, 1132–1136 W. Austin Avenue, Chicago, Ill.*)

Zinc Mining, Milling, and Smelting (4 reels, 35 mm.) (*Acme Educational Film Service, 1132–1136 W. Austin Ave., Chicago, Ill.*)

Manufacturing of Zinc Oxide (1 reel, 35 mm.) (*University of Wisconsin, Madison, Wis.*)

Suggested Chemistry Club Programs

Option (1). A poster exhibit on the uses of various common metals.

Option (2). Presentation of a motion picture in a related subject.

Option (3). A subject-matter meeting on topics related to zinc, magnesium, cadmium, mercury, and their uses.

No. 26. ALUMINUM AND AVIATION (March 10, 1932)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Aluminum—Poster, **8,** p. 689
The Story of Aluminum, **7,** p. 233
Some Commercial Applications of Aluminum, **7,** p. 245
A Visit to Hall House, **8,** pp. 181, 182
Demonstration on Thermite, **8,** p. 933
Aluminum in the South, **7,** p. 2383
Manufacture of Commercial Anhydrous Aluminum Chloride, **7,** p. 2376
Sapphires, **8,** p. 613
Man-Made Gems, **8,** p. 1015

Visual Aids

Slides

8 Slides on Aluminum and Compounds (*W. M. Welch Scientific Co., 1516 Orleans St., Chicago, Ill.*)

Motion Pictures

Chemical Effects of Electricity (1 reel, 16 mm.) (sale) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)

Magic Gems—Prisma (1 reel, 35 mm.) (*Film Classic Exchange, 265 Franklin St., Buffalo, N. Y.*)

Making Wear-Ever Cooking Utensils (1 reel, 16 and 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Suggested Chemistry Club Programs

Option (1). Subject-matter program in the "History and Modern Uses of Aluminum," illustrated by exhibits or posters.

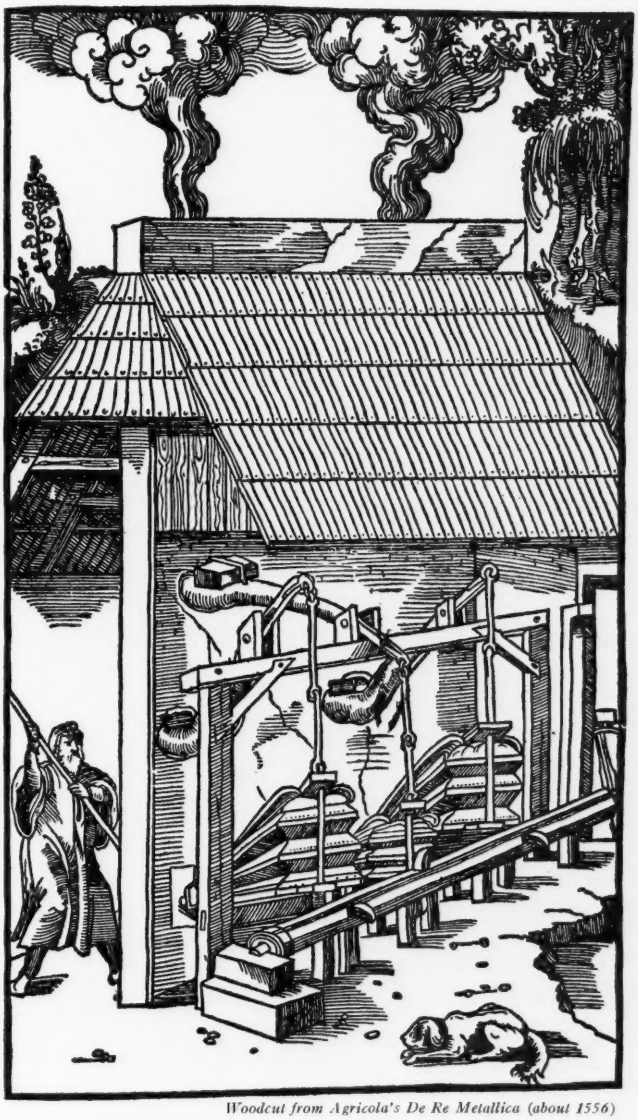
Option (2). Talk on "Modern Aviation" by an invited speaker.

Option (3). Visit to an airplane or airship hangar. (See *The Chemistry Leaflet*, Vol. IV, No. 34, p. 16.)

No. 27. TIN AND LEAD (March 17, 1932)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Lead—Poster, **8,** p. 693
Lead Tree, **6,** p. 355
Lead Trees Grown in Gels, **6,** p. 2228
Growth of Lead Crystals in Silica Gel, **7,** p. 1520
The Story of Paint and Varnish, **7,** pp. 515, 682
Paint and Varnish, **5,** p. 836
Electrolytic White Lead, Zinc Recovery, **2,** p. 1151
Tinning and Zincing, **6,** p. 555
Tin—Poster, **8,** p. 697



Woodcut from Agricola's De Re Metallica (about 1556)

MEDIEVAL IRON FURNACE

Historical illustrations and articles on the development of the chemical industries appear frequently in the publications of the Division of Chemical Education of the American Chemical Society.

Visual Aids

Slides

8 Slides on Tin and Lead (*W. M. Welch Scientific Co., 1516 Orleans St., Chicago, Ill.*)

Motion Pictures

Application of Chemistry (Manufacture of Storage Battery) (1 reel, 35 mm.) (*University of Wisconsin, Madison, Wis.*)

From Pigs to Paint (2 reels, 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Lead (1 reel, 16 mm.) (sale) (*Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.*)

Story of Lead Mining and Milling (3 reels, 35 mm.) (*Bureau of Mines, 4800 Forbes St., Pittsburgh, Penna.*)

Story of Lead Smelting (2 reels, 35 mm.) (*Bureau of Mines, 4800 Forbes St., Pittsburgh, Penna.; Indiana University, Bloomington, Ind.*)

Suggested Chemistry Club Programs

Option (1). Visit a manufacturing plant in which tin, lead, or some of their compounds are made.

Option (2). Exhibit meeting in which pewter, solder, tinned articles, lead, paints, and other articles made from tin, lead, or their compounds are on display.

Option (3). Presentation of motion pictures on related subjects.

No. 28. IRON AND STEEL (March 24, 1932)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Iron—Poster, **8,** p. 692

A Brief Lesson in the Chemistry of Pig Iron, **8,** p. 143

Relation of Chemistry to Iron and Steel Industry, **2,** p. 1125

The Bog Ore Industry, **7,** p. 1493

Utilization of Blast Furnace Slag in the South, **7,** p. 2393

Alloy Steels and Their Uses, **4,** p. 583

Visual Aids

Slides

47 Slides on Steel; and 78 slides on Iron and Steel; 24 slides on Iron (*Ideal Pictures Corporation, 26 E. 8th St., Chicago, Ill.*)

60 Slides on Iron and Steel Industry (*University of the State of New York, Albany, N. Y.*)

Motion Pictures

Arteries of Industry (4 reels, 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Blue Center (Wire Cable) (3 reels, 16 and 35 mm.) (*Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.*)

Continuous Process of Making Iron and Steel Sheets (4 or 2 reels, 16 and 35 mm.) (*American Rolling Mill Co., Middletown, Ohio.*)

Iron and Steel (1 reel, 35 mm.) (*Indiana University, Bloomington, Ind.*)

Making It Touch (3 reels, 16 and 35 mm.) (*Bureau of Mines, 4800 Forbes St., Pittsburgh, Penna.*)

Making of American Wire Rope (2 reels, 35 mm.) (*American Steel and Wire Co., 208 S. LaSalle St., Chicago, Ill.*)

Making of Steel (2 reels, 35 mm.) (*Indiana University, Bloomington, Ind.; International Harvester Co., 606 S. Michigan Ave., Chicago, Ill.; Iowa State College, Visual Instruction Service, Ames, Ia.; Motion Picture Bureau of the National Council of the Y. M. C. A., 120 W. 41st St., N. Y. C., also 300 W. Adams Bldg., Chicago, Ill.; University of Wisconsin, Madison, Wis.; Chicago Film Laboratory Inc., 666 Lake Shore Drive, Chicago, Ill.*)

Rolling Steel by Electricity (2 reels, 35 mm.) (*Acme Educational Film Service, 1132–1136 W. Austin Ave., Chicago, Ill.*)

Something New under the Sun (1 reel, 16 and 35 mm.) (*General Electric Co., 1 River Road, Schenectady, N. Y.*)

Speeding Production with Carboloy (1 reel, 16 and 35 mm.) (*Visugraphic Pictures, Inc., 247 Park Avenue, N. Y. C.*)

Steel for Sheets and Tin Plates (4 reels, 35 mm.) (*Acme Educational Film Service, 1132–1136 W. Austin Ave., Chicago, Ill.*)

Uses of Wire Rope (2 reels, 35 mm.) (*American Steel and Wire Co., 208 South LaSalle St., Chicago, Ill.*)

Suggested Chemistry Club Programs

Option (1). Visit to a blast furnace, a steel mill, an iron foundry, or a closely related industry.

Option (2). Presentation of a motion picture on a related subject.

Option (3). Exhibit meeting on the subject of "Everyday Uses of Iron and Steel."

No. 29. NICKEL, COBALT, AND MANGANESE (March 31, 1932)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Permalloy, **2,** p. 1157

Magnesium and Manganese, **8,** p. 1355

The Story of Nickel. Part I, **8,** p. 1749

Visual Aids

Motion Pictures

Mining Nickel and Copper Ore (1 reel, 35 mm.) (*University of Wisconsin, Madison, Wis.*)

Monel Metal (2 reels, 16 and 35 mm.) (*Rothacker Film Corp., 113–115 W. Austin Ave., Chicago, Ill.*)

The Manufacture of Nickel (*International Nickel Company, 67 Wall St., N. Y. C.*)

Suggested Chemistry Club Programs

Option (1). Presentation of a motion picture on a related subject.

Option (2). Demonstration of electroplating, with an exhibit of electroplated articles.

Option (3). Subject-matter meeting on the subject of "Nickel, Cobalt, and Manganese."

No. 30. CHROMIUM AND ITS RELATIVES (April 7, 1932)

No. 31. VANADIUM AND ITS RELATIVES (April 14, 1932)

No. 32. SOME OF THE UNFAMILIAR METALS (April 21, 1932)

Related Articles in Past Issues of the JOURNAL OF CHEMICAL EDUCATION

Demonstration on Chromium Plating, **8,** p. 933
Crodon, **2,** p. 1160
Metallic Tantalum, **2,** p. 1168
Carboloy—A New Tool Material, **5,** p. 1399
Demonstration of a Model Electric Lamp, **8,** p. 934
Illinium—Element Number 61, **5,** p. 561

Suggested Chemistry Club Programs

The annual spring chem-party could well be held at this time, with a two-week vacation from regular meetings in order to prepare for it. This may be a closed affair to which only the members of the chemistry club are invited, or it may be an open-house for other members of the school. The size of the school and local conditions will help decide this point.

For suggestions as to stunts suitable for a party of this kind, see Vol. IV of *The Chemistry Leaflet.* Numerous issues of this volume contained articles sent in from various chemistry clubs which had given successful parties. An especially good article on this subject may also be found in *The Chemistry Leaflet,* Vol. V, No. 2 (September 17, 1932).

No. 33. CHEMISTRY OF TRANSPORTATION (April 28, 1932)

No. 34. ACHIEVEMENTS OF YOUNG CHEMISTS (May 5, 1932)

Many young men and women have made notable contributions to chemistry and to the chemical industries while they were still in school, or shortly after they had been graduated. It will be the purpose of this issue of ***The Chemistry Leaflet*** *to present short accounts of some of the more interesting of the cases of this sort. Teachers of both high-school and college chemistry are requested to send in brief accounts of any of their former students who may have invented an important chemical product, or have otherwise done some exceptionally interesting thing in the line of chemical endeavor.*

Suggested Chemistry Club Programs

The annual chemistry fair or exhibit would serve as a fitting closing event for a successful chemistry club year. The fair or exhibit could vary in size with local conditions. Various references to the JOURNAL OF CHEMICAL EDUCATION listed on pages 1785 and 1786, contain valuable helps concerning exhibits. Especial attention should be called to an article in this publication on a Science Fair in Vol. 8, page 244.

. . . . . .

Although this outline is specifically intended for the use of teachers of first-year chemistry, the activities of the Division of Chemical Education of the American Chemical Society are considerably broader than the teaching of this one chemistry subject. For those who may not be familiar with the work of the Division, Dr. R. A. Baker, the secretary, has written the following outline of its activities:

The Division of Chemical Education of the American Chemical Society is a nation-wide organization of those who are interested in chemical education.

THE ANNUAL CHEMISTRY FAIR OR EXHIBIT WOULD SERVE AS A FITTING CLOSING EVENT FOR A SUCCESSFUL CHEMISTRY CLUB YEAR

General view of the high-school auditorium during a Science Fair at Senior High School, Roswell, New Mexico.

One of the objectives of the Division is to bring chemistry teachers everywhere into relations of mutual assistance and coöperation, thereby promoting not only high ideals of public service but also the advancement of the profession. The Division advocates sound principles of teacher training and selection, reasonable teaching loads, adequate salaries, well-equipped laboratories and libraries, and the systematic organization and correlation of chemistry courses.

The names of the standing committees of the Division indicate the nature and scope of the problems which are being actively studied and regularly reported in the JOURNAL OF CHEMICAL EDUCATION. The list includes Visual Aids in Chemical Education; Chemical Education of the Non-Collegiate Type; Chemical Education by Radio; Chemistry Clubs; Chemistry Libraries; Correlation of High-School and College Chemistry; Labels; Major Topic Organization of High-School Chemistry; Minimum Equipment for High-School Chemistry; Minimum Standards; Naming and Scope of Committees; Optimum Size of Classes; Order of Presentation of Recitation and Laboratory Work; Premedical Requirements in Chemistry; Preparation of High-School Chemistry Teachers; Research Problems; Teacher Exchange; Teaching Load; and Women's Club Study Course in Chemistry. (For the personnel of these committees see the third unnumbered page following the contents page in this issue of the JOURNAL OF CHEMICAL EDUCATION.)

Associate members receive the JOURNAL OF CHEMICAL EDUCATION as a part of their annual dues of $2.00. They are also invited to correspond about their problems with members of the Senate, with officers or committees of the Division or with the editors of the JOURNAL OF CHEMICAL EDUCATION and *The Chemistry Leaflet*.

One cannot weigh the professional satisfaction which comes from being identified as a member of a national association which is dedicated to the cause of chemical education. Every chemistry teacher should take pride in sharing the responsibility for the ambitious program mapped out by the Division. Finally, the united efforts of members of the Division toward the solution of mutual problems must inevitably result in professional advancement.

Those who have not already affiliated with the Division are invited to correspond with the secretary, using the form on the page adjoining.

Fill in the perforated sheet opposite and mail to

DR. R. A. BAKER, *Secretary*,

Division of Chemical Education

College of the City of New York

17 Lexington Avenue, New York City

Please detach this page and mail to:

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THE SCIENTIFIC METHOD IN PRACTICE

RICHMOND T. BELL, UNIVERSITY OF VIRGINIA, UNIVERSITY, VIRGINIA

Mathematics, physics, and chemistry inherently have greater possibilities for the encouragement of thinking than other subjects. Therefore they should be presented with this end in view. Any science is based upon experiment and classification. Thus it is in the laboratory that a science is best learned, and most is accomplished toward acquiring that coördination and association of observations, facts, causes, and effects known as thinking. The laboratory work is of primary importance from this standpoint with lectures parallel to and supplementing it.

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Within recent years the passive conviction that the educational system is basically unsound has led to active experiment, especially in colleges and universities. At the present time seven colleges and universities are experimenting with systems of education greatly changed from the classical American type commonly observed. This is based upon the assumption that all persons are capable of being educated. In a recent lecture on American education, Dr. Nock, of Columbia University, stated that student bodies in general are not capable of being educated. His definition of an educable person was a person who could accept discipline, and who could preserve an earnest, tolerant, and detached attitude toward life. This definition is general and not quite complete though the last phrase implies a desire to acquire the art of thinking. It might be added that an educable person is one who will try to acquire the power of thinking by thinking, by practicing, whether his latent brain power be high or low.

Some subjects are more suitable for thinking by doing than others. Mathematics, chemistry, and physics all have the necessary inherent qualities to a high degree, but to derive the most benefit from them they should be presented in a manner as scientific as that employed in solving the problems encountered in the advance of the science. A tabulation of results sought, factors involved in the solution, methods, or procedures, and final results should be made exactly as is done in the solution of any scientific research problem. This was done in solving the problem of education in general chemistry at this university. The final results indicate that, while not flawless, a scientific method of presentation is the best. In short, the same method used by investigators in developing the science is used in presenting the material of general chemistry to beginners. Naturally, a method of this kind encourages the power of thinking by practice, and the success attained in any particular case depends upon the extent to which a given student fulfils the above definition of an educable person. But in general, the inductive method which has been developed, based upon the student's own experiments in laboratory has been found to be better than any other method.

On the average, material presented in a course in general chemistry is the same. The difference in courses lies in variations and degree of emphasis. Excluding this possibility, logical improvements can be made only through organization and classification of the subject matter. The particular sequence followed in any individual case would depend on the scope of the course and the type of student constituting the majority of the class but in any event it is essential that laboratory and lecture work progress side by side as far as possible. Very often there is little or no connection between the two.

It is usually found that laboratory work begins with manipulations such as filtration, crystallization, etc., and continues with the nature of chemical change, elements, compounds, and mixtures. At the same time the lectures start with a chemical view of matter followed by descriptions of various simple elements. Then compounds and fundamental laws are gradually introduced. Laboratory work is minimized and from the start becomes a succession of isolated, unrelated experiments with no association for the aid of memory, and no logical sequence to encourage thinking and assist assimilation and understanding.

Any science is based upon experiment and classification. Thus in chemistry, as in any other science, it is in the laboratory that chemistry is best learned. Although text and recitation are relatively important adjuncts, their contribution is subsidiary to that of the laboratory. A successful laboratory system of instruction requires the collection, selection, and organization of a large number of experiments in order to enable a student to acquire the method of inductive thinking from his own observations. Laws, theories, hypotheses, and definitions are written generalizations of a series of observations. To understand them, and the difference between them, a student must learn to generalize from his own observations.

Admittedly then, learning general chemistry in the laboratory is an excellent plan, at least theoretically. Practically, a number of points might be brought forth which would appear to offer considerable difficulty. First, what experiments should be chosen to illustrate fundamental principles? Second, not all laboratories have either the facilities or the funds for extensive apparatus. Consequently, how much apparatus is absolutely necessary? Third, the same question is pertinent with regard to chemicals. Especially in high schools, the question of a large quantity of expensive chemicals is a serious consideration. Fourth, is the laboratory method of teaching by experiment rapid enough to cover the usual ground of fundamental and descriptive chemistry in only nine months?

The answers to these questions will be based upon observations made at the University of Virginia where this method of teaching general chemistry has been developed during the past ten years. While not perfect, the method has given satisfactory results, and it is believed to be considerably

better than a textbook procedure. The course thus consists of laboratory work interwoven with which is the actual teaching and explanation of lecture material.

A laboratory method would be expected to stress the importance of a laboratory notebook. If a student learns nothing else, the ability to take accurate, neat notes at first hand and derive correct conclusions from those notes is great justification for the method. If a student is able to make use of his own notes, with little recourse to other sources of knowledge, in order to pass the examinations to test his knowledge, he is on a par with the research investigator who makes use of his notes in like manner to solve his own particular problem. Only too often even the graduate student doing research for a higher degree has to spend some time acquiring this ability before making the progress of which he is capable.

A premium is placed upon accurate, neat notebooks in several ways. Permission is granted to use laboratory notebooks on one or more quizzes during the term, the quizzes being designed expressly for that purpose. Notebooks may be used in the identification of unknown substances. Notebooks may be consulted in the preparation of some substance that has not been prepared but whose method of preparation is analogous to that of other substances that have actually been made. Thus to be of any value the notebooks must, of course, be complete, accurate, and neat. They are kept in racks in the laboratory at all times and are written up in the laboratory continually as the work progresses. Primarily, the notebook is for the student's own information and it is obvious that with this system those students with the best notebooks would make the highest grades, exclusive of the fact that notebooks are graded unannounced once or twice during a term. Besides emphasizing the importance of the notebook, the system has the added advantage of eliminating excess memorizing at the expense of reasoning. The beginner in chemistry should assuredly have the same opportunity to think as has the original investigator who does not attempt to memorize all of his own and previous investigators' work before formulating a new conclusive bit of information or theory. The significance of the notebook has been discussed in some detail but this was deemed advisable since the notebook is an integral part of the system and the basis for the style of the laboratory manual.

The laboratory manual is written expressly for the laboratory method in use at this university. The lectures are grouped around the subjects and organization of subjects in the laboratory manual for the purpose of keeping laboratory and lecture work parallel. The manual is composed of eighteen chapters. By roughly scanning the material and arrangement of the laboratory manual, a general idea of the manner in which general chemistry is presented may be obtained. The chapters are as follows: Chemical Change, Metals and Non-Metals, Acids, Metals, Metallic Oxides, Bases,

Salts, Electrolytic Dissociation (this chapter concludes the work covered the first term), Oxidation and Reduction, Factors in the Speed of Reaction, Equilibrium, Neutralization and Its Use in Analysis, Some Applications of the Type Reactions, the Seventh Group of the Elements (this chapter concludes the work covered the second term), The Sixth Group of the Elements, the Fifth Group of the Elements, The Fourth Group of the Elements, Groups One, Two, and Three of the Elements.

The laboratory work starts with the sentence, "All scientific knowledge begins with classification." This sentence is the keynote of the laboratory manual and the corresponding method of teaching.

By means of the material covered the first term, the student is able to deal with all of the basic types of chemical calculations with the exception of oxidation-reduction equations and volumetric analysis problems. If he has had chemistry in high school, the work of the first term constitutes a thorough review coupled with new material from a different viewpoint. When the student has not had chemistry before, he finds the first term the most difficult of the three, but the foundation gained in this term through learning to think and to apply the scientific method himself proves, in the majority of cases, to be a better basis than that of the previous-chemistry student. The latter quite naturally tends to more or less ride through the first term on his previous knowledge, if any. This statement is supported by the fact although a no-previous-chemistry student may fall in a lower grade group at the end of the first term than a previous-chemistry student, he is almost invariably in a higher grade group at the end of the year when his grades for the three terms are averaged.

Oxidation-reduction reactions, a much dreaded topic in most courses, are taken up at the beginning of the second term. The method of balancing this type of equation was gradually developed at the University of Virginia and the final form as given in the present laboratory manual is believed to be as fool-proof as possible. Requests for the method have been made by both high-school and university teachers and in every case the use of the method has proved successful. The new significance of valence and the characteristics of oxidation-reduction reactions are logically developed in the several introductory paragraphs of chapter nine. After showing why the convention of calling the valence of an elementary substance zero was adopted, oxidation is defined as the loss of electrons (or increase in positive valence) and reduction as the gain of electrons (or decrease in positive valence). The first equation balanced by this method will be quoted from the laboratory manual to illustrate the method. The experiment is to examine the oxidizing action of the nitrogen atom in nitric acid when the acid is in concentrated solution. The data obtained consists of the facts that a brown gas is evolved and a blue solution is left after the reaction has stopped. The discussion of the reaction brings out the point that the

products of any reaction must, of course, be known, either by deduction or some other means.

Explanation.—The explanation, of course, consists simply in writing a reasonable equation which describes the observations.

To write this equation there are four steps to take. Since these same steps are necessary in all equations to follow in this chapter, it might be well to consider them carefully and commit them to memory.

(1) The atoms which gain and the atoms which lose electrons must be indicated. At the same time, it must be shown what probably happens to other atoms in the molecule when the valence of one atom is changed by loss or gain of electrons. In this case it may be shown as follows:

$$\begin{aligned} Cu - 2\epsilon &= Cu^{++} \\ HNO_3 + 1\epsilon &= H^+ + NO_2 + O^{--} \end{aligned}$$

It seems reasonable to assume that the hydrogen and oxygen exist in the condition shown because if the hydrogen had gathered electrons it would have become zero and come off as elementary hydrogen gas or if the oxygen had lost electrons it would have appeared as oxygen gas.

(2) The electron exchange must be balanced. Thus for all electrons gained an equal number must be lost. In this case:

$$\begin{aligned} Cu - 2\epsilon &= Cu^{++} \\ 2HNO_3 + 2\epsilon &= 2H^+ + 2NO_2 + 2O^{--} \end{aligned}$$

(3) There must be added a sufficient number of other ions to form such other products as are known to form in the reaction. In this case nitrate ions must be added to form the copper nitrate. Here, as in all cases where oxygen ions are formed, the ions should be added by means of acid molecules, thereby furnishing H ions for the oxygen.

$$\begin{aligned} Cu - 2\epsilon &= Cu^{++} \\ 2HNO_3 + 2\epsilon &= 2NO_2 + 2H^+ + 2O^{--} \\ 2HNO_3 &= 2NO_3^- + 2H^+ \end{aligned}$$

(4) The proper ions should be united and the total number of molecules or atoms involved should be added into one complete and balanced equation, thus:

$$\begin{aligned} Cu - 2\epsilon &= Cu^{++} \\ 2HNO_3 + 2\epsilon &= 2NO_2 + 2H^+ + 2O^{--} \\ 2HNO_3 &= 2NO_3^- + 2H^+ \\ \hline Cu + 4HNO_3 &= Cu(NO_3)_2 + 2NO_2 + 2H_2O \end{aligned}$$

The facility with which even the poorer students are able to grasp this method and balance complicated oxidation-reduction equations is more than sufficient evidence of its value.

Up to this point the student has had various reactions involving electrolytic dissociation as well as oxidation and reduction. Consequently at this time the student carries out chemical problems experimentally to show him how various reactions and principles might be applied in an industrial plant. The student conducts his own analysis, or manufactures

his product, calculates from his weights used and obtained the quantities that would be involved per ton of main product. He then submits a chart report which includes the equations of all reactions employed, quantities involved, and an estimate of the cost of a ton of product, based on market prices of the various chemicals, as he carried out the process. The student runs into difficulties which he solves as best he can, and makes mistakes which sometimes cause him to start over several times, but no more assiduous work is done on any part of the course. The lecture and laboratory work do not parallel each other during the progress of this problem. During this interval the periodic chart is historically developed up through elementary considerations of the present concept of the structure of the atom from chemical and physical viewpoints. The lectures then again parallel the laboratory in taking up the seventh group of the elements. Lecture and laboratory progress side by side throughout the course with the exception of the above instance. The seventh group of the elements begins what might be called the more descriptive part of the course. By this time the student is well grounded on oxidation-reduction and dissociation equations, and is capable of handling the various reactions of the atoms in the groups of the periodic table. The different valences of the elements provide a nucleus for a study of the reactions and chemical properties of the elements. The atom is taken from one to another of its valences and back again by means of carefully chosen reactions. This plan is continued throughout the other groups of the periodic table constituting the remaining chapters of the laboratory manual.

Charles Francis Thwing in *The Independent* several years ago said:

> Thinking is a practical art. It cannot be taught. It is learned by doing. Yet there are some subjects in the course which seem to me better fitted than others to teach you this art. . . . They are, I think, subjects which require concentration of thought; subjects which have clearness in their elements, yet which are comprehensive, which are complex, which are consecutive in their arrangement of parts, each part being closely, rigorously related to every other, which represent continuity, of which the different elements or parts may be prolonged unto far-reaching consequences. Concentration in the thinker, clearness, comprehensiveness, complexedness, consecutiveness, continuity—there are the six big C's which are the marks of subjects which tend to create the thinker.

Mathematics, physics, and chemistry all have most of the six connected with them. Chemistry, because of its far-reaching fields, has in abundance comprehensiveness and complexedness. Therefore it particularly should have consecutiveness and continuity to keep it from becoming a bewildering labyrinth of isolated facts. Chemistry is especially adapted to encourage the art of thinking, but to accomplish this in fullest measure requires that the method of presentation be as scientific as the subject itself

and then classification, "consecutiveness, and continuity" become of major importance.

The course in general chemistry at the University of Virginia is based upon the laboratory work. Lectures supplement and are parallel to the laboratory. In both, as especially brought out in the laboratory manual, the material is logically arranged to encourage thinking as much as possible and to minimize memory.

The Battle of the Rays. Modern physics may be said to have begun in 1895 when Professor Wilhelm Konrad Röntgen (1845–1923) accidentally discovered X-rays. In the thirty-five years that have elapsed, scientists, traveling the uncharted seas of radiation and radioactivity, have revealed a new world. Explorations into this scientific wilderness have hardly started and every day brings new discoveries. A list of the more understandable ones reported during the month of October, 1930, gives evidence of the fruitful activity that prevails:

1. Using gamma rays emitted by radium, scientists working in the U. S. Naval Research Laboratory have "looked" through steel girders and plates to determine the presence of weaknesses and defects. With a bit of radium hardly larger than the size of a bean, it has been possible to sensitize a photographic plate on the opposite side of a battleship's hull, a feat impossible with generally available X-ray equipment. This gamma-light photography, requiring nothing like the cumbersome equipment necessary in X-ray photography, will reveal defects in a metal as small as two per cent of its thickness.

2. Almost simultaneously with the demonstration of the usefulness of gamma-ray photography came the production of a giant X-ray tube at the California Institute of Technology, utilizing 600,000 volts, or more than double the voltage used in present "available X-ray equipment." Giant tubes such as this one may emit rays that have the therapeutic value of radium rays, and that will penetrate two inches of lead and two feet of concrete. Gamma-ray photography may not be so superior after all.

3. Professor Robert A. Millikan working far up in the invisible spectrum from the comparative long-wave gamma and X-rays, has been stalking the more elusive cosmic rays. His recent investigations indicate that they are not high-speed electrons but ether waves of exceedingly high frequency. If they were electrons, the rays' reception on earth would be influenced by the magnetic polar regions. To test this, Dr. Millikan took the electroscope with which he measures the rays to Churchhill, Canada, only 875 miles from the North Magnetic Pole. He made observations every day and night for a week, found the intensity of the waves the same in Churchhill as it was in his home in Pasadena, and concluded that cosmic rays bombard the whole earth equally. He also suggested that, since cosmic rays are affected by small changes of density in the air, the cosmic ray electroscope could be used to supplement the barometer in collecting information about the weather.

These three developments in the course of a month represent but a fraction of the discoveries in modern physics that are revealing the unseen activity of the universe. Sir J. H. Jeans, in discussing Millikan's cosmic rays, has speculated thusly on what it all may mean: "In a sense this radiation is the most fundamental physical phenomenon of the whole universe, most regions containing more of it than visible light and heat. Our bodies are traversed by it night and day. . . .it breaks up several million atoms in each of our bodies every second. It may be essential to our life or it may be killing us."—*The Technology Review*

A FRESHMAN COURSE IN CHEMISTRY IN AN ENGINEERING COLLEGE*

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Many engineering schools require a year of high-school chemistry for entrance and also emphasize the study of chemistry in the training given their men. The course as here outlined is based upon giving general chemistry and qualitative analysis as the first year's work. To accomplish this, emphasis is placed on the theoretical phases of the subject early in the course. Qualitative analysis and the study of the metals and their compounds constitutes the work for the second semester. The usual difficulties met with when such an arrangement is pursued have been modified by approaching qualitative analysis from a different angle than that usually chosen.

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To shape a given course so that it shall be of most value to those taking the work is the aim of every teacher. In a liberal arts college where the class is composed of individuals looking forward to many different lines of work the chemistry course is quite varied in subject matter and in methods of attack. The so-called "pandemic" chemistry serves the purpose where the class is definitely not going into scientific work. In an engineering school, however, we deal with boys who have already chosen a general line of work. Here it is possible to shape the course to the needs of the group in a very helpful way and to accomplish more in the same length of time.

Many of the engineering schools are now requiring for entrance high-school credits in chemistry, in physics, and in mathematics through solid geometry. This should bring to such institutions a group of boys whose interests are along mathematical and scientific lines. Since they all have had work in chemistry there should be some elementary chemical knowledge on which the college course could be built, the possession of which would lighten somewhat the work of the freshman year. By means of a placement examination in chemistry given the first week of school and by a study of the grades made in quizzes throughout the year we have sought to determine what concepts and actual abilities the entering freshman has brought with him. The conclusion we have reached is that although a few come with an excellent foundation most of them have very little on which a college course can be built. This means, then, that unless some system of grouping can be worked out, the first year's course must take a somewhat middle ground and, while mentioning practically every elementary principle, must pass quickly over some and require the student to look them up more completely outside of class.

What do we expect to accomplish with these men during their freshman year? It is an accepted principle that an engineer must have a thorough scientific and mathematical foundation and every engineering school of

* Presented before the Division of Chemical Education at the 81st meeting of the A. C. S. at Indianapolis, Indiana, March 31, 1931.

standing requires all its men to take a year of general chemistry. When the fields of engineering in which the school is interested are further restricted, as at the Colorado School of Mines, to the four fields dealing with the mineral industries—metallurgy, mining, petroleum, and geology—a thorough training in chemistry becomes even more important. While no degree in chemical engineering is definitely offered yet a man taking a degree in metallurgy or in petroleum refining must have chemical training almost equivalent to that required of the chemical engineer. Besides the freshman work, courses in quantitative analysis, physical chemistry, and, for some, organic chemistry are required and many specialized courses in the various options are waiting to be given when this foundation in chemistry is completed. The first-year chemistry course, therefore, becomes equal in importance to any other course in the school. To further complicate matters, the curriculum is so crowded that qualitative analysis cannot be postponed to the second year, as is often done, but must be included in the first year's work if it is to be presented at all.

Accepting the freshman, then, as he comes to us with his smattering of chemical knowledge, we are expected in a year's time to lay such a foundation in general chemistry and qualitative analysis that he can build on it advanced courses in chemistry and allied subjects. In accomplishing this we have found it necessary to reduce to a minimum any discussion of descriptive and historical aspects of the subject, devoting the time, instead, to fundamental chemical principles. Also, we found that we must devote more time to the study of the metallic elements than is allowed in many courses. The boys we work with are looking forward to employment in the mineral industries and need to know all we can teach them regarding the metals. Finally, as we all know, repetition at intervals of time plays an important part in the learning process. If a topic can be presented early in the course and then made use of as the work proceeds the student becomes familiar with the concept and it becomes a tool which he can use. These three principles have been the ones we have had in mind as we have planned the course.

Chemistry presents two principal lines of study—the constitution of matter and its behavior. We start with the study of the structure of substances as expressed in the molecular, atomic, and electronic theories. We feel that the molecule and the atom should be somewhat familiar units to the freshman, while the electronic concept will advance him into new and interesting fields. All too frequently, however, we find the boy unable to derive any significance from a formula such as H_2O, either in terms of atoms and molecules, or in terms of weights concerned. The arrangement of the elements in the periodic table is introduced as a systematic grouping based on structure and properties. The history is practically omitted and the table presented as a chart to be used constantly, the in-

telligent reading of which constitutes one of the objectives of the year's work.

The gaseous, liquid, and solid states of matter are surveyed, followed by a study of solutions and of colloids presented as mixtures of substances differing primarily in degree of dispersion. Before ionization is taken up a general discussion of acids, bases, and salts as three classes of compounds is given. Then the ionized condition is discussed, more from the modern angle than from the historical viewpoint.

Having treated the subject of the structure of matter we next turn to the study of its behavior. This involves the examination of the chemical reaction. We spend considerable time on this topic studying the various types of reactions, the characteristics, the quantitative relationships, the energy changes involved, its reversibility and the methods of controlling the resultant equilibrium. Reactions are examined from the standpoint of any shift of electrons which may take place. Oxidation and reduction have been treated from the first as involving such electron shift or valence change. Emphasis is placed throughout on developing the ability to predict, with reasonable accuracy, the products which will be formed. The electromotive series of the metals is constantly used as a means of predicting probable reactions and the stabilities of certain classes of compounds.

As the close of the semester approaches we turn to the study of the non-metals and their compounds. We use the long form of the periodic table and take the group as the basis of study. The similarities and the dissimilarities in atomic structure are brought out and the chemical conduct of the free elements is correlated with this structure. The compounds formed with hydrogen are first studied as typical hydro acids and then the compounds with oxygen are taken up. This is followed by a survey of the compounds formed when the oxide combines with water. These oxy acids are treated both as hydrated oxides and as hydroxides of non-metals. The former treatment is especially important with our men, since so many of their geological formulas are written in oxide form. The acid radical is treated as the group which sets one particular acid apart from others. This radical is then followed into the salts formed from the acid and its stability and general behavior in such compounds is noted. The emphasis at this stage is placed on the behavior of the salts as a group of compounds related to a given acid. The study of important individual salts is postponed to be taken up in connection with the study of the metal constituents. Since our men all take work in geology and mineralogy we also find it helpful to spend some time on the topic of the condensation of simple acids into the more complex types by removal of water. The acids of silicon are used as the class material for this.

If time permits we spend about a week on the compounds of carbon at this point. If not noted here, it is generally put off until the last part of

the second semester's work. Our petroleum men will later take a semester course in organic but with the others the freshman course is the only time they receive instruction in such work.

The laboratory work of the first semester is confined to one three-hour period per week. It is planned to be different from the high-school course and to be quantitative in character wherever possible. The regular analytical balances used by our sophomores in quantitative analysis are available and the freshmen become familiar with them. This is helpful the next year. When the study of the non-metals is taken up in class as outlined above, the laboratory work is devoted to a more qualitative study of the reactions of these elements. This is planned to lead into the study of the anions, with which we open the qualitative work of the second semester.

The laboratory work for the second semester consists of work in qualitative analysis. Two three-hour periods per week is the time allowed. We have modified the order of attack quite radically, seeking to present qualitative analysis in a way most helpful to our engineering students. In another year we expect to have most of the rough spots smoothed out and then we will be ready to outline in more detail the work as we give it.

From the classroom standpoint we have before us at the opening of the second semester the task of surveying the metals and their compounds, of discussing the theoretical topics related to the qualitative course, such as solubility product, complex ion formation, etc., and of drill in equation writing and prediction of reactions.

As we all know, correlation of the study of the metals with work in qualitative analysis is very difficult. We have tried both of the usual methods—one where the metals are discussed in the order of their qualitative grouping and the other where the periodic table is followed—and have come to the conclusion that the periodic grouping is the better one to follow. In the laboratory we begin by studying the anion analysis first. This follows nicely the work of the last week or two of the first semester and also gives us time to get the survey of the metallic elements under way in the classroom. There we discuss the occurrence, metallurgy, commercial preparation, properties, and uses of the metals. Then we examine their oxides, hydroxides, and any important salts. When the laboratory work reaches the point where the given metal is to be studied we approach it from the standpoint of the behavior of the metal ion—its reduction and its oxidation, solubility relations of its various salts, and use of its chemical characteristics in separating it and devising tests for it. This gives us an opportunity to review and compare the behavior of the free element with its behavior in the ionized form.

All this time we have been making use of the general principles and theory outlined during the first semester and it is not unusual to find the men able to state with fair accuracy the important facts regarding a

metal or some of its compounds after having located it in the periodic table and the electromotive series even though no text study of the metal has been made.

Looking forward to the work of the sophomore year in quantitative analysis, we devote a week of class work to the study of oxidation-reduction in general. At the very beginning of the year's work we define oxidation-reduction in terms of loss and gain of electrons, and toward the close of the first semester, in discussing the non-metals, we have called particular attention to their oxidizing-reducing behavior. The discussion of the topic as a whole—which comes about the tenth week of the second semester—then becomes, in part, a review of this very important subject and we feel it serves to correlate many points in connection with chemical reactions in general. By using the reactions of potassium permanganate and potassium dichromate as class examples we make it somewhat easier for the men when they meet these reactions the next year in their quantitative analysis.

In closing each semester's work we have found it very profitable to devote one or two class periods to a survey of the subject. We ask the student to step back, so to speak, from his text and watch us as we try to bring out in bold relief the line of thought running through the entire course. In our opinion, these lectures are probably the most valuable ones from the standpoint of the student.

In this paper we have outlined a first-year course in chemistry planned for young engineering students who have had a year's work in high school. It has been shown that by eliminating much descriptive and historical matter and by introducing fundamental principles as early as possible in the course one can accomplish the work which is generally planned for both the general chemistry and the qualitative analysis courses.

Finds Soap and Water Valuable Germ Killers. Common ordinary soapsuds, particularly hot ones, are extremely good agents for killing germs, Dr. John E. Walker of Opelika, Alabama, has recently reported to the American Medical Association. The germs of pneumonia, meningitis, diphtheria, syphilis, gonorrhea, influenza, and the streptococcus germ were all killed in about two minutes by comparatively weak solutions of soap in cool water, Dr. Walker found from his own and other investigations.

The soapsuds compared favorably with many newly synthesized chemicals in germ-killing power. The brand of soap apparently made no difference, brown laundry soap, floating white soap, perfumed toilet soap, cocoanut oil and olive oil soaps, and soap made according to the standards of the U. S. Pharmacopeia were equally effective.

"When properly used for cleaning the hands or for washing eating utensils, soaps are undoubtedly potent factors in preventing the spread of diseases due to these organisms," Dr. Walker concluded.

However, the germ of typhoid fever and the staphylococcus organism are not destroyed by soaps, he added.—*Science Service*

THE CHEMIST IN THE RUBBER PLANT*

BERT S. TAYLOR, RAW MATERIALS DEPARTMENT, THE B. F. GOODRICH COMPANY, AKRON, OHIO

Changing business methods in the United States during the last twenty years have brought a demand for and created an appreciation of the chemist. The routine chemist has his part to play in American industry. Illustrations are drawn from the rubber industry to show the work which the average chemist has before him. The transition from university to factory work offers new problems to the chemist and new tools with which to solve these problems. The principal function of a technical man in industry is as the guardian of quality. This rôle applies equally to the technical executive and to the routine chemical analyst. This work extends itself to the final use of the goods in the field, and the presence of numerous technical men in sales and customers' service work today proves their value. In many factories a training period is given to the new men to familiarize them with the methods of production and the tools necessary to production control. This training period also introduces the new men to the special materials and methods of his particular industry. Complete information about the materials used and the best way to use them is one of the greatest assets to all chemists who go into technical work in industry. A broad knowledge of other branches of science such as physics, especially mechanics, as well as a knowledge of cost accounting is necessary for most effective performance of the technical man in the plant.

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Industry in the United States has received great impetus in the last twenty years. The cry for higher quality, lower cost, and new or better products has created a heavy demand for chemists and chemical engineers because of the discoveries and developments brought about by technically trained men of the past generation. The value of a technical staff is fairly well appreciated by all industry. Those forms of manufacture which are largely chemical depend wholly upon chemical developments for their business. Not only in chemical industry, however, but in fabricating industries depending solely upon mechanical means to transform raw materials into finished articles the chemist is of value. American industry owes much to the chemist as exemplified by men such as Dow, Baekeland, and Langmuir, but it owes more in the aggregate to the thousands of unnamed chemists who are responsible for the high quality and strict uniformity of American goods today.

The rubber industry combines mechanical manipulation with chemistry. The process of vulcanization either with sulfur and heat or by sulfur chloride in the cold is a chemical process. Most of the formative processes, however, involve principally physical changes. Illustrations of the value of

* Delivered as part of the students' course in Industrial Chemistry held at the 13th Exposition of Chemical Industries, New York City, May, 1931.

a chemist in industry and his place in the manufacturing world will be drawn from the rubber industry but his value could equally well be demonstrated by examples from other fields of manufacture.

To industry the young chemist brings a background built on his university experience. One of the first reactions about which he learns as a student is that hydrogen combines with oxygen to form water. This is a clean-cut, quantitative reaction. Similarly, most of the reactions of elementary chemistry and even of advanced college work are straightforward according to theory and are used to demonstrate the theories of chemistry. It is not until he gets into applied chemistry in industry that processes, by-products, and side reactions assume great importance to his mind. The combination of rubber with sulfur accomplishes certain ends which can be measured by the change in physical properties. It is impossible to explain this change by any straightforward chemical explanation. Certain rules have been formulated to follow in the manufacture of rubber goods but even today with all the fundamental work which has been done very little is known about the chemical changes which take place during vulcanization.

In the university the student contacts with his fellows and with his teachers. With the former he is not forced to associate to any greater extent than he cares to. With the latter he seeks to establish a record of achievement based on recitation, laboratory reports, and quizzes. Presumably the instructor can evaluate his knowledge of the subject which is being taught. Whether the man is shy, conceited, or possesses other qualifications which determine how smooth and effective will be his human relationships is a matter of minor importance so long as he is able to convince the faculty that he has learned the lessons assigned. In industry, however, he faces a different problem. Not only must he be able to convince a critical immediate superior that he is capable of effective work but by sheer force of personality he must day by day convince those working at his side, whom he cannot escape if he would, that he is capable of steady, continuous effort, that he is ingenious (can use his head, they would say), possesses sound judgment, and is absolutely honest in all his dealings. These human traits we sum under the term "personality" and the chemist in industry must have the human touch, aggressiveness, and a sense of humor, as well as technical ability and ingenuity if he is to win success.

The chemist with four years' training in a good college or university usually has sufficient grounding in the fundamentals of the science to attack most of the problems of the industry. Frequently, however, he lacks perspective in the particular industry which he is entering. He cannot tell without a broad view of its scope and processes what effect a change in materials or operations at one point will produce at another. Before he can avoid serious difficulties in his work he must have such knowledge. It has, therefore, become the practice in many firms to give young technical

men entering their employ a special course of instruction to broaden their understanding of the industry and to bring them quickly to the point of effective operation.

Men entering our Training School start to work in either the General Chemical Laboratory or in the Mill Room. Men in the laboratory change places with men in the Mill Room until the whole group has had the complete period of training. In the Mill Room the men actually operate the large mixing mills, weigh out batches, and assist in the preparation of calendered stock. This physical experience with the machinery of the rubber industry gives them a background which can never be lost and fits them for much better service later. During this preliminary training period talks are given to the men by executives of the company and by leaders in certain departments of the organization. For example, there have been discussions of crude rubber fabrics, rubber compounding, time study, and almost every individual phase of rubber manufacture. It is not expected that the men will become efficient rubber technologists at once due to the three months' training course which they receive. It is rather hoped that their interest will be stimulated in various fields of the work and that they may make a choice of the field in which they would best like to work. After all, this synthetic experience is exactly the same as that which is obtained all through the field of education. We try to tell others in a short time the things which have been learned at the expenditure of a great deal of time and thought. If in order to become a good organic chemist every man had to prepare all of the compounds which have ever been made before he could investigate new ones there would be no progress. In the same way, if every man had to spend ten years in the rubber industry before finding out enough by his own personal experience to become a good rubber compounder, it would take a long time to train men and the industry would not be as far along as it is now.

Promotion out of the chemical laboratory at the close of the training period may be into any one of a number of fields of rubber manufacture. By this time the manager under whom the chemist has worked has had a chance to size up his ability and is able to place him to the best advantage. Chemically trained men have been placed in the sales department, in the purchasing department, and in the cost department. However, about 80% of the chemists ultimately go into one of the technical departments of the manufacturing division and most of these become compounders. The duties of the compounder are the control of the quality of the finished article, the making of adjustments in methods of manufacture or in the types of materials used in order that the finished article may meet the service required. It is also his duty to devise ways and means of reducing manufacturing and materials cost. One cannot consider any form of manufacture today without mentioning cost. The reason the American chemi-

cal industry is in the position it occupies today is because of efficiency and cost reduction, which have been brought about in the last few years. The technical man too often forgets the cost side of the picture in looking at his results. This may cause him disappointment that many of his ideas are refused. Costing methods have their foundation in economics and common sense and are easily followed with an elementary knowledge of accounting principles. No technical man who enters industry should fail to take advantage of every opportunity to learn about cost. Most rubber goods are sold by the piece—that is, according to a fixed volume. Yet rubber and compounding ingredients are purchased by the pound. It is, therefore, desirable where service will permit to secure as large volume as possible for the number of pounds purchased. In determining the finished cost of rubber goods it is necessary to consider both the specific gravity and the pound cost.

The foregoing considerations apply equally to other branches of science as well as to costs. Physics and mechanics are being applied to the study of manufacturing methods to a greater extent now than ever before. A reaction which will go beautifully in a test tube may fail miserably on a large scale because of failure to consider the heat laws. The study of physical properties of rubber by means of stress strain data is merely applied mechanics. The construction of a tire is just as much a piece of engineering as the building of a bridge. A thorough consideration of the strength of each part and the influence of load and pressure must be given in order to be sure of finished quality.

A college alumni association in Cleveland has adopted the slogan, "Don't just get educated; keep educated." For the chemist in industry this is wholesome advice. Chemistry is a dynamic science, industry is a developing organism, changes and improvements and new knowledge are ours to utilize every day. The chemist cannot remain inactive in a moving world. He must continue to learn, to do old things in new and better ways, to do new things that have never been done before. For the rubber industry the young chemist needs particularly broader knowledge of physics with special reference to mechanics and heat than he usually possesses. Other industries may require optics or electricity. Whatever the requirements, the chemist must use his own efforts to educate himself if he is to advance.

The chemist or chemical engineer who enters the rubber industry usually becomes a compounder. The individual compounders are each in charge of the quality and behavior of a selected group of rubber mixtures which are called compounds. Each of these compounds goes into a definite rubber article or part of an article. Making 32,000 different articles representing over 1000 distinct rubber products, it is not surprising to find that there are approximately 1500 compounds and that 700 of these are active nearly all the time. The compounder is essentially a materials

engineer. He must know what each material is used for and fit it to its proper use. There are at present over 300 pigments, about 16 grades of rubber and approximately 15 distinct reclaimed rubbers. Add to this 20 accelerators of vulcanization and 4 or 5 age resistors and the result is quite a list from which to pick. The total number of combinations is almost limitless, particularly when we consider that variations in percentages play an important part in changing the ultimate quality of the rubber compounds.

The chemical reactions involved in the manufacture of rubber goods are not clean-cut chemical reactions. One of the best methods of learning about the constitution of cured rubber articles and about the materials which enter into the manufacture of these articles is through analysis. The laboratory work gives the young chemist a chance to become familiar with the factory and manufacturing methods in a general way and above all else fits him for the position of compounder which he may later fill, by giving him the opportunity to become familiar with the materials used.

Roughly speaking the materials of the rubber industry are divided into four classes—crude rubber, reclaimed rubber, pigments, and organic chemicals. This last group includes accelerators of vulcanization and age resistors.

Crude rubber is the product of the plantation rubber industry in the Far East. Very little chemical control is possible on crude rubber. Reclaimed rubber, however, being a product of the chemical industry, is controlled by chemical analysis. Reclaimed rubber may be made from shoes, hose, or miscellaneous mechanical goods, but the greatest amount of it is made from old tires and inner tubes. To a large extent the physical properties of a finished rubber article containing reclaim depend upon the qualities of the original reclaimed rubber.

The group of materials classed as pigments is by far the largest group of the four since it contains not only dyes and colors but every material used in rubber compounding which does not fall into any other classification. In determining the value of a particular material as a rubber compounding ingredient it is necessary to find out how it fits the following specifications:

1. Chemical activity
2. Particle size
3. Particle shape
4. Dispersibility
5. Cost and specific gravity
6. Quantity available.

In order to have the widest use a satisfactory pigment should be chemically inactive. Whiting (calcium carbonate) cannot be used in rubber compounds which are made to resist acid. The next three qualities may be evaluated by saying that the ultimate dispersible particle should be less than 0.001 millimeter in diameter in order to give the best physical properties. It is

obvious that regardless of how fine a material may be made it is of no value unless it can be properly mixed into rubber. The volume cost, which is obtained by a joint consideration of the pound cost and specific gravity, should be low. The quantity available should be unlimited. Several times in the past it has happened that a material was used to a small extent at a very reasonable price until an article of major importance was made from it. When this occurs a shortage develops almost over night.

The last class of rubber compounding ingredients was that of organic chemicals. Organic accelerators which are used in rubber goods shorten the time of vulcanization and improve the quality of the finished material. These include such substances as thiocarbanilide, hexamethylene tetramine, diphenyl guanidine, and aldehyde amine condensation products. Organic accelerators were discovered by A. H. Marks and George Oenslager in 1906 and represent one of the outstanding contributions of a chemist to rubber technology. Age resistors retard the oxidation and deterioration of rubber during aging.

The fundamental reaction underlying the rubber industry is termed vulcanization. When rubber is heated with sulfur in the presence of such materials as zinc oxide, lime, lead oxide, magnesium oxide, or one of the organic compounds known as accelerators the sulfur combines with the rubber. Vulcanization changes rubber from a plastic to an elastic material. This sounds very simple but the mere statement of this combination does not explain all of the physical changes which take place. By using increasingly large amounts of sulfur we can go from the physical properties of a rubber band or inner tube to that of a hard rubber battery container. It is safe to say that most soft rubber articles have less than 5% of sulfur combined with the rubber. The remainder of the differences are brought about by the use of other compounding ingredients.

Control of quality is the prime function of the chemist in the plant. This control may be applied not only to the raw materials used in the manufacture of goods but also to packages, labels, wrapping paper, inks, adhesives, and the hundred and one smaller materials which serve nearly every manufacturer.

The importance of raw material control is not appreciated unless a careful survey of usage is made. For example, we use zinc oxide as an aid to vulcanization in practically every rubber compound. In no compound is it used in any greater amount than essential because of its high volume cost. We may take 5% of the total recipe as a representative amount. A carload of zinc oxide contains 80,000 pounds. Should the man analyzing this material fail to discover that it is off quality a tremendous quantity of finished goods would be lowered in quality. Of course, production control might catch the mistake in the factory, but this control could not function until a large amount of defective material had been produced.

Control of quality applies also to unfinished goods at various stages in the process. For example, in the electrodeposition of metals it is necessary to take an occasional sample from a plating tank in order to determine the concentration of metal salts in the batch. In the same way, in the rubber industry it is necessary to run a control test for the amount of sulfur in a mixed batch before the batch can be cured. It is not always expedient to run a control analysis for sulfur on an uncured batch to be sure it will cure. It is generally more simple to cure a small piece of the mixed batch and if the vulcanized product seems to have the correct snap and hardness the mix is considered to be satisfactory.

The chemical control of the finished goods involves almost every form of analysis as does also the analysis of competitors' products. The development of service tests is also important work in the works laboratory of any plant. This does not usually depend upon an exact duplication of service conditions but rather upon an acceleration of certain factors which may cause deterioration of the product. Great care must be taken in this work that in running an accelerated test false results are not obtained. Many times if only one factor of breakdown of an article is considered, entirely wrong results will be obtained. Examples of this kind of work are testing of air hose, resistance of paint spray hose to lacquers, studies on tank lining compounds against special chemicals, the list is almost endless.

In addition to analytical work, the chemist in the works laboratory has an opportunity for a large number of plant problems. These plant problems are always the most interesting phase of the work for they involve not only rubber goods but almost every branch of manufacture and chemistry.

The following may give some idea of the varied nature of the plant problems which are submitted to our chemical laboratory:

The determination of the cause of defective hose couplings.

The development of a new tire paint for dressing up a super grade of tires.

The cause of deterioration of the fabric used in conjunction with zipper fasteners.

Studies on the accelerated aging of rubber goods.

Solution of these plant problems requires a liberal amount of "horse sense" as well as chemical knowledge.

By analyzing the causes of breakdown or elimination of goods from service the designer of the product can measure quantitatively those factors which have brought about failure. This analysis of performance of a product in the field quite often leads to the installation of control standards in the factory so that subsequent articles may be of uniform and high qual-

ity. In the manufacture of platens for typewriters, cash registers, and other types of printing machines, a definite hardness has been found to be essential. Hardness control for this type of goods, therefore, is part of the regular routine of manufacture.

In the university, accuracy is a prime requirement and speed is of relatively less importance. In industry accuracy of manipulation and accuracy of results are still demanded of a plant chemist. Speed of operation, however, assumes a larger relative importance. Speed is often of as much value as accuracy although the two must go hand in hand. A sample, perhaps one-half pound of accelerator, pigment, raw batch, or other form, comes to the laboratory for test. This test must be rushed. Why? Because there are 20,000 pounds of batch stock held up until the tests are completed. These 20,000 pounds represent 50,000 automotive articles of parts which have to be shipped tomorrow. Unless fast work is done, factory production is shut down, deliveries are held up and sometimes even the customer's factory has to stop production because of slow chemical tests. The result may even be the loss of some important business.

In certain instances a progressive chemical change is accompanied by a progressive change in physical properties. This is true in the vulcanization of rubber. The chemist who enters plant work very quickly finds that there are faster ways to measure the degree of vulcanization than by the analysis for combined sulfur or even by the determination of stress strain or tensile strength. Hardness is much used as a control test for the determination of the curing ability of batches of rubber in process. Given a sample of rubber, it may be cured and the hardness determined in twenty minutes. The determination of total sulfur by the ordinary method of chemical analysis will take not less than twenty-four hours. The sulfur determination requires chemical laboratory accuracy, careful weighing, preparation of reagents, ignition of the final barium sulfate precipitate. The hardness control test requires only curing the sample in a heated press and measuring the amount of compression under a fixed load for a definite time. Often for the sake of economy, a chemist must desert his chemical procedure for a faster test after a definite relationship with the chemical change is established.

Industry has progressed in stages. First came the inventor who devised a new machine, a useful material, a novel article. Then the engineer took control, devised effective methods of production, reduced costs, and standardized the product. Finally, the research scientist entered the field, analyzed the products and the processes of manufacturing into their physical and chemical components, measured progressively the effects of varying compositions and methods of production and put the industry on a scientific basis. All industry has not gone this far. There is still a broad field of endeavor for the research chemist and research physicist.

As we look back through the years to the time of Charles Goodyear the relative unimportance of rubber in his day is surprising considering the fact that today it is considered a necessity in many lines of manufacture. At that time it might be compared in importance to shellac today. There were no outstanding characteristics which made it of extreme value and for which it alone could be used. From a substance which in winter was hard and brittle and in summer was soft and sticky the discovery of vulcanization by Charles Goodyear in 1839 changed it to a material of extremely desirable physical properties. The developments of the chemist have been of primary importance in bringing about the extended usage of rubber. After vulcanization was discovered the number of products in which rubber could be used became more and more diversified and during the nineteenth century a large number of mechanical goods were developed which had been impossible previously because there were no known materials from which to make them. There are many people today who can remember when the first automobile tire was made and yet this article is the one which consumes the greatest quantity of rubber and rubber compounding ingredients. It is safe to say that the rubber tire today makes other rubber articles cheaper through increased production of raw materials and yet the development of the tire was only possible by using the experience gained in other forms of rubber goods and by the scientific investigation of rubber compounds. Today the chemical industry is supplied with rubber-lined tanks and pipes for handling corrosive liquids, ventilators and fans for acid fumes, belts for conveying dry chemicals and foodstuffs, hose tubing, valve and pump parts. Finally, there is a rubber-lined tank car for delivery of the product which must be kept free from contamination.

It is evident that in order to apply new materials and methods on a production basis there must be in the production organization technical men, chemists, physicists, engineers, capable of understanding the principles and methods involved in production to detect immediately the causes of difficulties, to remedy them, and to pick up quickly the results of laboratory studies and translate them into profitable manufacturing processes. The foreman or manager of a production department who understands the technical nature of the product he is making is better able to keep his department running satisfactorily by catching troubles at the outset rather than after money has been wasted through the production of large quantities of defective goods.

The reverse of this condition is just as necessary. There are needed in the research laboratories of chemical industries men who have had production experience. These men, through their experience, realize the needs of the production departments and by putting these needs on a working laboratory basis quite often can solve production problems much faster than a man who has had no plant experience before entering research work.

It is not uncommon for users of manufactured products to fail to secure the expected service from the articles they have purchased. They do not know the conditions under which the materials from which the article is made will yield the maximum satisfaction and length of useful life. Even though these are known they may be unable to change their own processing to secure the greatest benefits. The manufacturer of the original article is faced with loss of business. In such situations the technical man again offers his service. Frequently his personal investigation of the user's operations will indicate how satisfactory service may be secured either by modification of the goods or of the user's processes. The difficulty is removed and a more loyal customer is retained. This is not exactly a sales job but combines the work of development with that of the application of manufactured goods to certain requirements. The large corporation today owes its success to the service rendered to its customers. For example, the automotive industry purchases large amounts of miscellaneous rubber goods. Every rubber manufacturer has one or two development men who can go into the automotive factory and determine its needs and develop articles of rubber that will fit the service required. This kind of work requires a good deal of experience not only in chemistry but engineering. Sometimes it is necessary to convince the purchaser that the particular type of article which he wants will not fit the needs at all but that something entirely different can be made to do a more satisfactory piece of work. Ingenuity in demonstrating the applicability of ideas and a sound knowledge of engineering are necessary to success in this field service work.

In every chemical industry there are men who have been affiliated with that particular type of manufacture for ten, twenty, and thirty years. Only a few of these men are technically trained but they have one great asset which the new chemist does not possess—namely, experience. Entirely too often the intolerance of a young technical man for the experience of an older man has hampered his progress. The rubber industry is founded on the work of chemists and chemical engineers. It has presented an opportunity for service to technical and non-technical men alike.

The chemical industry today in its highly competitive position requires of all its technical men the maximum of service and loyalty.

The men in charge of chemical industries, in general, appreciate the difficulties of new men coming into the organization and what I have said of the necessity for control accuracy and speed as well as the personal qualifications applies equally to all industrial work. The basis for success in any chemical industry is to learn the most about the materials which that industry uses and about the best methods employed in using these materials. These requirements, coupled with a sound fundamental knowledge of that part of chemistry and chemical engineering which is the foundation of the particular industry, play a major rôle in the success of the chemist.

INDUSTRIAL SCHOLARSHIPS AND FELLOWSHIPS*

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A lax terminology obtains with respect to the use of the terms "scholarship" and "fellowship." For the sake of clarity, the designation scholarship should be restricted to a grant essentially for the assistance or support of a student; a fellowship, however, should relate to a similar grant to a scientist or other person fully qualified to pursue research. Almost all colleges and universities have scholarships of the classic type, usually permanent, for the aid of worthy students, some in specified subjects and some without such restriction.

Industrial scholarships, on the other hand, are usually of temporary character. The aim of some of them is to sustain disinterested research on a problem assigned by the company or association interested. Then, too, we have the scholarships founded by industrialists which permit of research on problems selected by the faculty. Sometimes it is understood or implied that the donor will have first chance to secure the services of the student after graduation if he so desires. Thoughtful industrialists look upon the graduate scholarship as an investment, inasmuch as its founding may be regarded not only as a means of repaying in part their debt to pure science, but as an aid in the training of men for useful service. Most of the students eventually find their way into teaching, pure science research, or industrial investigation; no matter which career is followed, industry finally benefits.

There is also the true type of educational fellowship, namely, those grants, either temporary or permanent, that enable the men selected, holders of the Ph.D. degree or its equivalent, in each case, to pursue advanced, protracted scientific investigation under suitable facilities. In some instances, the recipient is permitted to choose the institution where he works. The National Research Fellowships are representative of this general class.

A totally different type of fellowship is the basis of the research procedure at Mellon Institute. By the system of this institution fellowships, one year in length, are sustained by manufacturing companies or associations and are assigned to properly qualified persons, usually specialists. Assistants to these fellowship incumbents come under the scholarship class, inasmuch as they have the opportunity to pursue graduate work in the University of Pittsburgh, with which Mellon Institute is allied coöperatively.

In the paper the procedures followed in founding and operating scholarships and fellowships under industries' auspices are evaluated. Special attention is given to industries' appraisal of the benefits that are derivable from such research grants.

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* Contribution to the symposium on "Coöperation between Industry and Chemical Education," held under the auspices of the Division of Chemical Education, at the 81st meeting of the A. C. S. at Indianapolis, Indiana, March 31, 1931.

A lax terminology obtains with respect to the use of the terms scholarship and fellowship. For the sake of clarity, the designation scholarship should be restricted to a grant essentially for the assistance or support of a student, either undergraduate or graduate. The term studentship, as used in Canada, is even more definitive. A fellowship, however, should relate to a similar grant to a scientist or other person fully qualified to pursue research.

We have National Research fellows and we have fellows of Mellon Institute—these are proper designations—but we should not have "fellows" who are undergoing undergraduate or graduate training in educational institutions. In other words, the term fellow should be limited to a man who is fitted to pursue investigational work, having completed his actual university training. This idea is in consonance with the recognized use of the term in England. It is there a mark of distinction. Too often what are merely scholarships are termed fellowships, with a consequent misunderstanding and misinterpretation on the part of donors and prospective donors. There is, in fact, widespread confusion in the use of these designations. Mellon Institute, for example, is frequently misunderstood to be a school of the University of Pittsburgh. While it is indeed an "inchoate school of specific industries," it does not offer courses of instruction; it has fellowships, and not true scholarships.

Types of Scholarships and Fellowships

Almost all colleges and universities have scholarships of the classic type, usually permanent, for the financial aid of worthy students, some in specified subjects and some without such restriction. Other scholarships, more frequently referred to as fellowships, are supported in educational institutions by the industries. They are usually awarded to graduate students but sometimes to undergraduates. The aim of such grants, which are generally of temporary character, is to sustain research on a specific problem of importance to the company or association interested. Then, too, we have the scholarships founded by industrialists in graduate schools which permit of research on problems selected by the faculty thereof; the results, if any, are usually published. In another and more formal type, the problem is selected by the industrial donor and the results, if any, belong to the donor. It is sometimes understood or implied that the latter will have first chance to secure the services of the student after graduation if he so desires.

Finally, we have the true type of research fellowships, namely, those grants, either temporary or permanent, that enable the men selected, holders of the Ph.D. degree or its equivalent in each case, to pursue advanced, protracted scientific investigation under suitable facilities. In some instances, the recipient is permitted to choose the institution where he works.

The fellowships of the National Research Council are representative of this class. These fellowships are most frequently and most properly concerned with pure science investigations, that is, disinterested research.

A totally different type of fellowship is the basis of the research procedure of Mellon Institute. By the system of this institution fellowships, one year in length, though usually renewed year after year, are sustained by manufacturing companies or associations and are assigned to properly qualified persons, usually specialists. Assistants to these fellowship incumbents come in the "scholarship class," inasmuch as they have the opportunity to pursue graduate work in the University of Pittsburgh, with which Mellon Institute is allied coöperatively.

The Basic Idea of Research Grants

In this consideration of the subject attention will first be accorded to the underlying philosophy as well as to the development of what can be termed the fellowship idea in industry and education. There will be attempted an evaluation of the success that in general has attended the application of various kinds of scholarships and fellowships.

The underlying principle of scholarships and fellowships of all types is, in origin, attributable to the recognized obligation of society to nurture the advancement of knowledge and to aid in the extension of educational procedures that have this worthy objective. The prime aim of the fellowship idea is the encouragement of original discovery, and hence, in extension, the support of efforts to advance scientific knowledge. In addition, there is the other aim of training men in research methods for useful careers as pure and applied scientists.

In essence, therefore, the scholarship and fellowship idea originated in, and has been developed by, a purely utilitarian motive, the same motive that is apparent in all worthwhile philanthropic contributions to education and research. So far in this section reference has been had principally to pure science research grants. In the case of scholarships or fellowships that are concerned with problems of interest to the donors thereof, it is plain that the foundational motive is one of commercial or business expediency. There is no question that this type of grant is utilitarian in character.

One of the determining factors in the acceptance of scholarships in some institutions has been their interference with the consulting practice of faculty members. In such institutions graduate assistants who can aid in such consulting work are sometimes preferred to scholars or fellows. It happens, however, that in certain institutions industrial fellows or their equivalent are accepted by faculty members if retainers for them are provided by the donors. In those cases the faculty members profit just as much from research grants as they do from straight consulting work.

At Mellon Institute members of the executive staff are not permitted to engage in consulting practice nor to accept outside remuneration for their advice or work. At Lehigh University, where a similar system is in operation, it is understood that the purpose of the fellowship is to do usefully productive investigation and to train promising young scientists and engineers for careers in the industries, and that at that institution the consulting work of faculty members is kept separate from the fellowships.

General Considerations Respecting Industrial Fellowships

The industrial fellowship should provide for the investigation of problems of specific importance to the industries, the solution of which will mutually and materially benefit both the manufacturer himself and the public. The underlying thought of every industrial fellowship procedure is that each useful agent in our life of today is the product of an industry and that it is only through the industries that these novel products of civilization become available to the public. It does not matter whether the holder of an industrial scholarship or fellowship is receiving graduate training or is already a specialist; in every instance he is appointed to pit his strength, training, and creative ability against a problem that is of technologic significance. If the fellowship is founded and sustained by a manufacturer and the latter decides upon the problem for investigation, it will be understood that this problem is of technical importance because it has been chosen by one who has inner knowledge of the conditions of the business.

An arrangement of this character is more conducive to satisfactory relations and is more stimulating to the ambitious fellow than one where the problem is selected and assigned by a faculty member who is not intimately conversant with industrial needs. Too often the teacher of applied science does not realize that he is, after all, usually on the outside of industry and has merely an extramural connection therewith, notwithstanding the frequency of his visits to plants and the extent of his consulting practice. It must be admitted, however, that only through industrial connections can he acquaint himself with actual industrial practice.

This brings us face to face with the question as to what type of problem can best and most properly be handled by a university. Because the question involves so many institutions and faculties of varying competence, so many fellows of varying capacity and training, and such widely differing donors and problems, it is almost impossible to answer it specifically. Some men seem to be productive of creative research no matter where they work or under what conditions. It is the writer's opinion, however, that the university or college is and should be primarily an educational institution whose greatest service to industry is the thorough training of young men for careers as scientists.

It is believed that the research in universities which is sustained by grants

from the industries should in general be of broad fundamental nature; that the subjects studied should be of interest to and supported by the largest possible number of industrialists; that this support should be in fact coöperative. The more industries that contribute to sustaining a research and the more money they spend, the more each one of them and therefore all of us profit. There is some question as to the right of a university endowed by private, state, or federal funds to devote its time and money to the solution of the problems of a single company. It is indeed thought that university industrial scholarships will contribute more of value if the problems investigated are chosen by the faculty and students themselves. It follows then that the true industrial fellowship—working with problems of product or process development—can best be carried on in institutions organized and conducted for that purpose.

In expressing the opinion that industrial fellowships on definitely practical problems of individuals or firms should not be accepted on a fellowship basis by a university faculty, no criticism of the teacher himself is implied. It is felt that the situation would automatically and properly adjust itself were the salaries of these men raised to proper levels.

It is believed, then, because of the public nature of an educational institution and its responsibility for the broad, theoretical training of youth, that the definitely practical and commercial aspects of research are best studied in the research laboratories of industries or by industrial research fellows working in institutions definitely incorporated or administered for the purpose, the financial support coming wholly from the industries.

Another reason for the sound practicality of this arrangement is that a process or a patent may be both an asset and a liability. The industrial research of a university should in no wise involve that institution in legal and business entanglements. The system of procedure worked out at the University of Michigan, though not separately incorporated, is doubtless quite satisfactory. This system as well as those in use at Purdue, Cincinnati, and elsewhere should be discussed at some time by those competent to do so.

There should be no objection to the research institution working coöperatively with a university as it may profit much from educational contacts and library facilities.

The Value of Industrial Research Grants

From an economic standpoint, industrial scholarships are necessary because for good men it is so often impossible to remain in school beyond the four years required for the bachelor's degree. This is true more than ever at the present time. Without scholarships it would be impossible to provide means for many of the financially dependent students, a group from which many of our most creative men develop. Many thoughtful in-

dustrialists look upon the graduate scholarship as an investment, inasmuch as its founding may be regarded not only as a means of repaying in part their debt to pure science, but as an aid in the training of men for useful service. Most of the students eventually find their way into teaching, pure science research, or industrial investigation; no matter which career is followed, industry finally benefits.

Further, these industrialists know that through their contact with the faculty a knowledge and appreciation of their work and their problems are acquired by the teacher, useful to him in his training of men for the industries and in stimulating him, occasionally, to do research of his own on fundamental data of industrial interest.

From those industrialists who have supported scholarships from this broad point of view there has come little criticism. To those who have expected a definitely tangible return, the results have not always been so satisfactory.

It is said that too often faculty members, in their desire to obtain research grants of obvious advantage to the university and to themselves, fail to study the problems carefully enough from the standpoint of their probable solution in the time given, overlooking their own lack of time for supervision and the lack of suitable apparatus and facilities. Another criticism has been that there is too often a dearth of management, which is most evident in the lack of systematic progress reports and a comprehensive summary report at the termination of the project. Lack of contact with industry, often given as another reason for ineffectual scholarships, is not always wholly the fault of those on the academic side of the counter.

The main reason, as stated by one research director, himself a professor of science, for the weakness of university industrial research is "lack of organized opinion as to procedure."

May we hope that further discussion of this important topic may lead to crystallization of opinion and a closer and more effective coöperation between the industries and chemical education.

Tooth Enamel Consists of Apatite Crystals. Apatite, appropriately enough, is one of the constituents of teeth, it appears from a report of the Superintendent of the Physics Department of the National Physics Laboratory, London. In normal teeth the enamel consists of apatite crystals together with a second crystalline substance, at present unidentified, the report states. The National Physics Laboratory has been making a preliminary study of the crystal structure of teeth at the request of the Dental Research Board.

Apatite is not an emotion but a mineral made up of calcium, fluorine, and phosphorus. It occurs in various-colored six-sided crystals. It is a common source of phosphorus, and the mineral is exported as fertilizer by Norway and Canada.—*Science Service*

ATOMIC MODELS FOR USE IN TEACHING INORGANIC CHEMISTRY*

EWING C. SCOTT, SWEET BRIAR COLLEGE, SWEET BRIAR, VIRGINIA

All atomic models are true, as far as they go. The fact that the Lewis-Langmuir-Bury model has for certain purposes been superseded by a system of equations does not diminish its extreme usefulness in teaching chemistry. A mechanical model of this atom has been devised which is unusually simple to construct and possesses other advantages. The most important feature is that the valence electrons are detachable, and that every atom beyond hydrogen has spaces for the completion of its valence octet. Only three different models are needed to show all the atoms of the first three periods of the periodic system. Actual gain and loss of electrons in the formation of polar compounds, and the sharing of electron pairs in single and double bonds can readily be shown. Most simple molecules can be constructed, as NH_4ClO_4, CO_2, and SrS_2O_7. Bury's explanation of the multiple valence of the metals of the first transition series can be demonstrated. These models have greatly aided in the teaching of both elementary and advanced students in the following subjects: electron theory of oxidation and reduction, octet theory of valence, polar and non-polar bonds, ionic theory, and the distinction between Na and Na^+, and multiple valence.

. . . . . .

It is rather fashionable these days to inveigh against the use of mechanistic pictures to explain any of the data of chemistry or molecular physics. According to Dr. Saul Dushman, for example, "Thou shalt not make unto thyself any graven image of the atom or anything that is within the atom, nor bow thyself down before them nor worship them." We must forego their convenience for fear that we shall be hampered by their limitations and be blind to the possibility (or even to the observation) of new facts and relationships if there is in our model no analogy to correspond to them. The finger of warning points out the changes that have come over our old billiard-ball atoms, and the moral is drawn against putting our trust in *any* physical picture of an atom. We are even beginning to be told that we must abandon our beloved tetrahedral carbon atoms and trust ourselves to the tender mercies of substitution groups when we venture into the realms of stereochemistry.

The fact remains, however, that we think more easily in terms of the concrete than of the abstract. Particularly, we *learn* more easily that way. If a familiar concrete illustration can be found which has a one-for-one correspondence with a new set of facts and relationships, the latter are already as good as learned. When the correspondence goes so far that the illustration enables new facts to be predicted and discovered, its useful-

* Presented before the Division of Chemical Education of the A. C. S., Indianapolis, Indiana, April 1, 1931.

ness is, of course, even greater. We have been warned that people tend to jump to the conclusion that a successful model is not merely an illustration, but the ultimate reality; but I, for one, fail to be greatly alarmed. Minds capable of creative thought can hardly conceivably be fettered by the bonds of a rigid picture. The long succession of atomic models which have one after the other made their contributions to truth and been *superseded* by better ones should be sufficient proof of this.

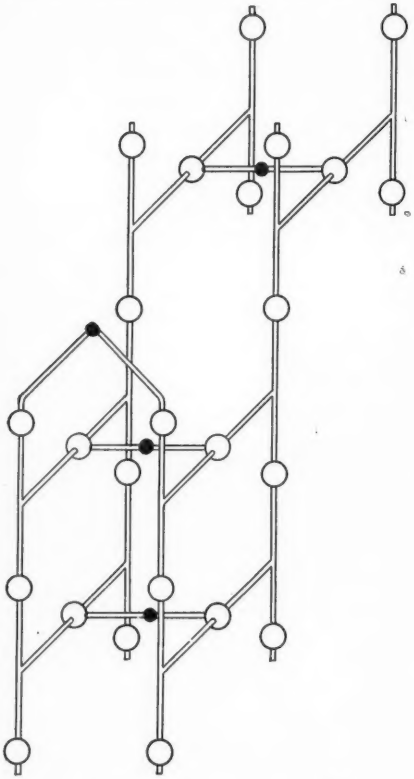


FIGURE 1.—A FORMATE ION, $HC(=O)-O-$

This configuration shows a carbon atom attached by a single bond to one hydrogen and one oxygen atom, and by a double bond to another oxygen atom.

There are those of us who feel, then, that each modern theory should be made use of in its place and as long as it will serve; who do not wish to occupy the ground of the late Dr. Ostwald, who for years objected to the atomic theory because it *might* not be true, and to his dying day stood on the beach trying to order back the incoming tide of the ionic theory because it was not necessary in order to describe the facts. If a theory can be represented in an easily understood model, so much the better. In particular, the modern pictures of the structure of the atom are useful to the teacher of inorganic chemistry, and without any serious danger even in the case of elementary students if care is taken to separate facts from theory and to make it plain at the beginning, and all along the way, to what extent the model is merely a diagrammatic representation of the data.

Do not ask the question, "Which model is the true one?" All the models of the atom have been true, and still are in their field. Kendall is very right in saying, "The acceptance of new views does not involve the rejec-

tion of the old." Even the billiard-ball atom is still true, in all that mystic realm of thermodynamics based on the perfect gas law. In the early days of the nuclear atom there was war to the knife between the static atom of the chemist (such as Lewis' cubical one) and the dynamic atom of the physicist (such as Bohr's original plane model) but as usual both were right, though both were trying to claim too much. They have gradually worked toward each other until they are essentially identical. The chemists are now willing to admit that what they call the position of an electron may be the aphelion of an elliptical orbit, and the physicists, notably Stoner, have adopted the division of the electrons into layers (although they call them groups of a given total quantum number) put forward by Langmuir and so much improved by Bury. True, the atom has now fallen into the hands of the mathematicians, who threaten to leave us nothing but "an aura surrounding a void," but their adumbrations do not destroy one jot or tittle of the truth of the more concrete model associated with the names I have mentioned.

The model which I have chosen to illustrate, which may properly be called the

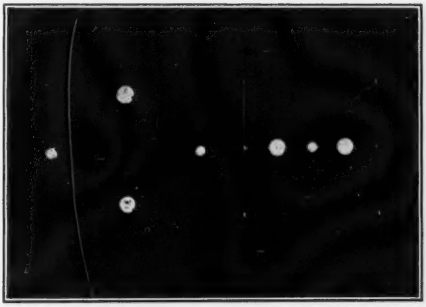


FIGURE 2.—A H_2 MOLECULE AND A HE ATOM. THE LATTER IS ALSO H^-, Li^+, Be^{++}, AND B^{+++} IONS AND THE KERNEL OF 1ST GROUP ATOMS

The small balls represent the nucleus of any atom, according to what charge is assigned. The large balls represent electrons.

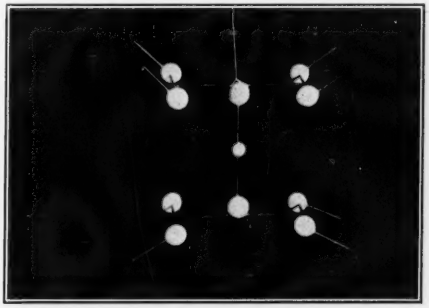


FIGURE 3.—NEON ATOM, ALSO N^{---}, $O^=$, F^-, Na^+, Mg^{++}, AND Al^{+++} IONS; KERNEL OF 2ND PERIOD ATOMS

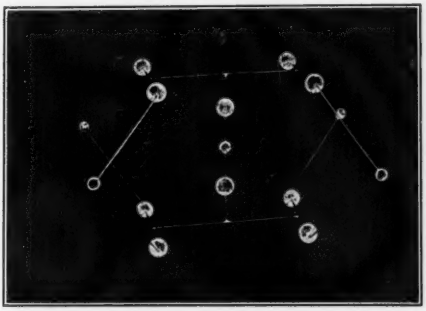


FIGURE 4.—AN NH_4^+ ION, ALSO A CH_4 MOLECULE, IF NO DISTORTION IS ALLOWED FOR

Bury atom, does not claim to be truer than several others. It does, however, exemplify a large amount of *chemical* truth, with a minimum of extra chemical complication. Especially valuable is Bury's idea of never putting more than eight electrons in the outside layer, and later, when a group of eight in the third or fourth layer is no longer on the outside, filling it up to eighteen or thirty-two. This affords the only reasonable explanation of the variable valence metals and of the existence and number of the rare earths.

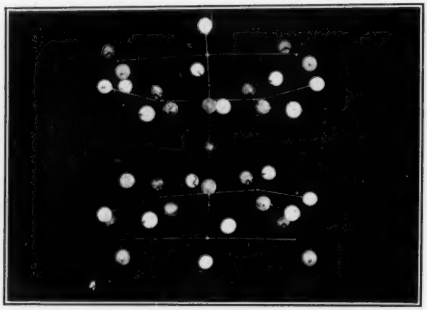


FIGURE 5.—KRYPTON ATOM, ALSO $Se^{=}$, Br^{-}, Rb^{+}, Sr^{++}, AND Yt^{+++} IONS

This frame is the same as that in Figure 6, except that since it provides places at the poles for the completion of the 3rd layer of 18 (shown in pure white); all atoms of the 3rd period instead of only those up to Ni^{++} can be built on it. For ease in distinguishing, electrons of the different layers are shown in different shades.

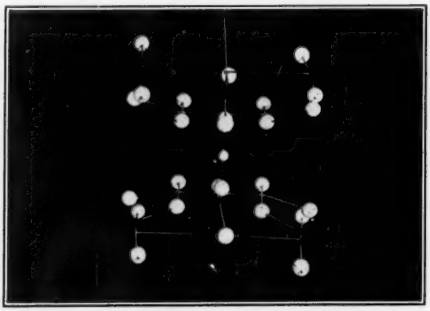
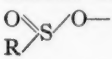
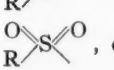


FIGURE 6.—IRON ATOM

Shown with 8 electrons in the 4th layer (a possible explanation of "passivity"?), showing the 8 unfilled places in the 3rd layer which account for variable valency according to the Bury theory. VO_4^{---}, $CrO_4^{=}$, MnO_4^{-}, and TiF_4 would be made by substituting this structure for the central atom in Figure 7.

In view of the difficulty of three-dimensional visualization, even when assisted (if it *is* assistance) by the instructor's attempts at picturization on the blackboard, a set of actual physical models was made. In the design of these models certain new features were incorporated which are believed to be a considerable improvement over anything which has previously been used. The first of these is the skeleton structure. As a result of this the wires entering any one ball, representing an electron, are all in one plane, so that the plaster of Paris balls can be cast in place with a simple two-piece mold. Also, the models can be telescoped for storage, with a great saving in shelf space. The other feature is that the valence electrons are detachable.

The detachability of the valence electrons is an extremely valuable feature in teaching. It makes possible actual demonstrations of all the things

pictured in the chapters on the octet theory common in modern texts. The electronegativity of the non-metals and the electropositivity of the metals, oxidation and reduction, polar valence, and ionization are all made plain by the simple removal of an electron from a sodium atom and its addition to a chlorine atom. Non-polar bonds, both single and double, can be shown with ease. It is *possible* to show a triple bond by making use of the tetrahedral distortion theory (although I personally agree with G. N. Lewis that no such thing as a triple bond actually exists). The formation of an ammonium ion is made easily understandable, and it becomes very plain how the ions of the acids of chlorine increase in oxygen content up to a maximum of four while the valence of the ion remains the same. The nature of Sugden's semi-polar bonds is made obvious, and the demonstration of the equivalence of the oxygen atoms in the common oxy-acids reveals the futility of such discussions as those in Mellor (*1*) as to whether sulfur in an alkylsulfinate ion is to be represented as quadrivalent  or as hexavalent  , or whether sulfite

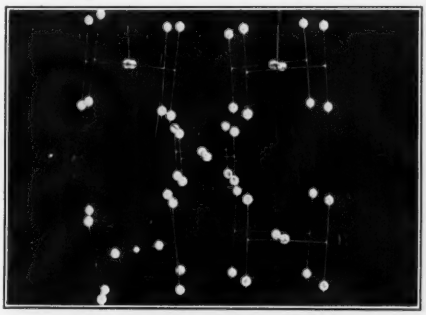


FIGURE 7.—SiF_4 MOLECULE, ALSO PO_4^{---}, SO_4^{--}, SiO_4^{--}, AND ClO_4^- IONS, ACCORDING TO CHARGE OF NUCLEUS OF CENTRAL ATOM

The valence layer of first period atoms is made the same size of that of second period atoms, in order to facilitate showing non-polar bonds.

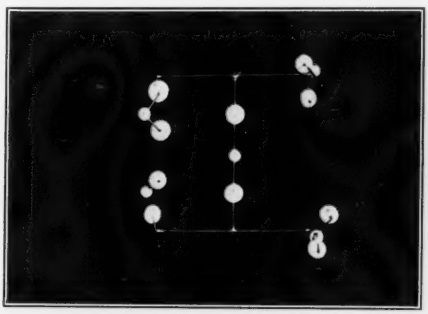


FIGURE 8.—A CH_4 MOLECULE, DISTORTED INTO TETRAHEDRAL FORM

FIGURE 9.—A C_2H_2 MOLECULE, SHOWING TRIPLE BOND

ion is $\begin{matrix}-O\\-O\end{matrix}\!\!>\!S\!=\!O$ or $\begin{matrix}-O\\O\end{matrix}\!\!>\!S\!<\!\!\begin{matrix}O\\O\end{matrix}$. Finally, by the use of a larger model, showing the empty spaces in the third layer and valence electrons in the fourth, it is possible to show the first transition series, and explain the multiple valence of the metals from titanium to copper.

An incidental advantage of the use of movable electrons is that a single model, by having the proper charge ascribed to its nucleus, may be used for all the elements in any one period of the periodic table. In addition to the simple bit of wire which serves for a hydrogen atom, only three different models are needed to show all the atoms up to krypton, together with Rb^{+}, Sr^{++}, and Yt^{+++} ions.

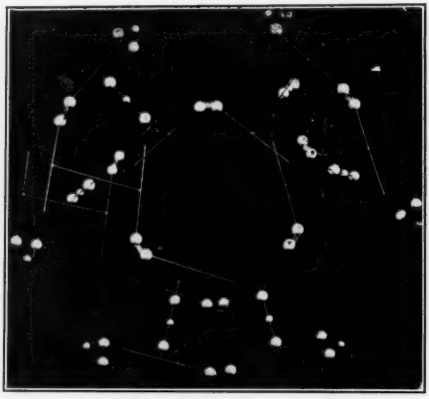


FIGURE 10.—A C_6H_6 MOLECULE, ACCORDING TO THE KEKULÉ FORMULA

This illustrates how double bonds permit flexion but not rotation and how single bonds permit both, if the bonding electrons are drawn together.

These models have been used in the instruction of classes in general and advanced inorganic chemistry for three years in the premedical school of the Peking Union Medical College, and for four years at Sweet Briar College. It is believed that they have been a great help to both lecturer and students.

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Practical Details.—The hardest grade of drawn (not cast, on account of welding difficulties) brass wire, of about B and S gage No. 10, is a convenient material for making the frames. It can most easily be joined by spot-welding, though oxy-acetylene welding is also satisfactory and perhaps necessary if the jaws of the spot-welder are not conveniently shaped. The detachable electrons are cast on one-inch sections of brass tubing of such a size as to slip easily over the wire of the models. The ends of the tube can be crimped slightly with pliers in order to obtain the correct degree of friction.

Molds for casting electrons can be made as follows. Miter four small pieces of wood and fasten them with a rubber band into the shape of a bottomless box. Set this on a glass plate, fill with a thick plaster of Paris mixture, and press a ball bearing of convenient size into the surface until half buried. Smooth off and flatten the surface. As soon as the plaster has set thoroughly remove the sides of the box, the glass plate, and the ball bearing. The surface of the mold may then be trued up with a coarse

flat file if necessary, and the channels for the wires around which the ball is to be cast may be cut out with a pocket knife. After thorough drying give the mold a good soaking in melted vaseline and grease well with the same material before each use. Before use, molds should be paired by placing the ball bearing between two halves and trimming the edges to fit. A groove or two made across the edges on one side will serve to identify a pair and to enable the halves to be fitted together in the same way each time.

A battery of eight or nine molds can conveniently be filled at one time with a mix of 45 g. of plaster of Paris to 25 g. of water. After all the halves are filled the first will probably be thick enough so that it will not spill when inverted for joining to its mate around the desired wire. Rubber bands hold the halves together. An hour is ample time to allow before unmolding.

Literature Cited

(*1*) MELLOR, "A Comprehensive Treatise on Inorganic and Theoretical Chemistry," Vol. X, Longmans, Green and Co., New York City, **1930,** pp. 238–9.

Radium Rays Live Only Fraction of Second. A short and adventurous life of a hundred millionth of a second is enjoyed by an alpha ray from radium after being imprisoned in the nucleus of the atom for a period which may range from less than a year to one thousand million years.

Lord Rutherford recently described here the results of his long researches in radioactivity in these terms in a lecture to the Royal Institution. Despite its hectic life after escaping, he continued, the brief period of activity of the alpha particle has been so thoroughly studied that we are better acquainted with its character and adventures than we could ever hope to be with the character and personality of a distinguished citizen.

"The alpha particle has played a great part in the development of physics," said Lord Rutherford. "It provided the first evidence of the transmutation of elements. . . . It first afforded the opportunity of detecting effects due to a single atom, thus furnishing, for the first time, definite proof of the truth of the atomic theory. By its aid, also, an early. . . estimate was made of the dimensions of the atom. . .

"It was, moreover, by studying the scattering of alpha particles that the nuclear structure of the atom had been revealed, a peculiarity which constituted the basis of all modern views on the nature of the atom. The alpha particle had also proved invaluable in investigating the forces reigning at the heart of the atom, and had been applied with great success to the artificial transmutation of the light elements. . . . .

"The nucleus of an atom constitutes a minute world of its own. If an atom of radium were magnified to the size of the lecture room, its nucleus would be smaller than a pin head. . . . In some sense we might regard the nucleus as analogous to a drop of water which was held together by surface tension, but the analogy was a very rough one. In the case of the nucleus, the surface tension of the water drop was replaced by a potential barrier of great height, through which the particles inside were unable to escape . . . The height of the barrier at its crest might be as much as 20,000,000 volts."—*Science Service*

THE PROJECTION OF LECTURE EXPERIMENTS*

HARRIETT H. FILLINGER, HOLLINS COLLEGE, VIRGINIA

A projection lantern for opaque objects has been found useful in projecting lecture experiments. Details often seen by only a small portion of the class when experiments are carried out on the lecture desk in the usual fashion may be made clearly visible to every member of a large class.

Some of the lantern's uses, as demonstrating the relative degrees of ionization of strong and of weak electrolytes as shown by conductivity of electricity and chemical reaction experiments, the suppression of ionization of weak electrolytes as shown by indicators and decreased chemical activity, fractional precipitation, and double refraction of Iceland spar are discussed, and the experiments described.

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For several years the author, by using an opaque projection lantern of the balopticon type for the projection of lecture experiments, has successfully made the details of such experiments clearly visible to each member of a large class.

Experience has taught that even in the best arranged lecture rooms, those students at a distance from the desk often miss the main point of the experiment through failure to see the most significant details of the reaction. For instance, even though relatively large quantities of material are used, the evolution of gases, relative rates of evolution of gases, color changes, etc., cannot be seen by more than a small portion of the class when such experiments are carried out in the usual fashion at the lecture desk. In an attempt to overcome such difficulties it occurred to the writer that such experiments might be carried out to advantage in a lantern and the magnified image projected upon a screen. The results have been very successful with the simple experiments for which the lantern is constantly used.

In the hope that the idea may prove helpful to others a few of the experiments which have been carried out easily and effectively by this means are briefly described. The experiments have been purposely set up without any special arrangement of lantern or any additional equipment of the usual lecture room other than a small piece of mirror. The experiments used have been kept simple in the belief that the least elaborate set-up which will demonstrate the principle in question is the most satisfactory because it gives the student a better opportunity to direct his attention to the reaction rather than to the apparatus required to manipulate it.

By inserting small ammeters and voltmeters in the lantern and projecting them, the small pointing needle and the scale of inexpensive pieces of apparatus are converted to dimensions of several feet. The ammeter is used in making a rough study of the relative effective degrees of ionization of acids and bases as indicated by differences in conductivity of solutions

* This paper was presented in part before the Division of Chemical Education of the A. C. S. at Richmond, Virginia, April, 1927.

of equivalent concentration. Normal solutions of hydrochloric, phosphoric, tartaric, and acetic acids and normal solutions of sodium and ammonium hydroxides are generally used in this experiment. The voltmeter is used in discussions on batteries, or the generation of electricity by chemical action. The ammeter or voltmeter is the only portion of this set-up which is placed in the lantern, the remainder of the apparatus being on the lecture desk. If the lantern is one that must be placed some distance from the desk, wires for attaching the electrical apparatus can be permanently run from the desk to the lantern.

Differences in effective degrees of ionization as indicated by rate of chemical action easily lend themselves to being carried out in the lantern. For instance, if small lumps of marble of equal size are placed on separate watch crystals, very low-form crystallizing dishes, or flat-bottomed petri dishes, in the lantern and small amounts of $6N$ hydrochloric, phosphoric, and acetic acids, respectively, are added separately to the samples of marble, very marked differences in the rate of evolution of carbon dioxide can be noticed in the images of the reactions which are projected side by side on the screen. The action of acids on other salts and on metals can be used similarly to illustrate the same point. If the elements are chosen from different positions in the Electromotive Series of Metals and used with the same acid, these experiments may be used to indicate differences between the activities of the metals. To demonstrate the effect of particle size on the rate of chemical action, zinc graded in several sizes from powder to quite coarse granular particles and $6N$ hydrochloric acid may be used. These experiments rather obviously indicate that the lantern permits a more careful study of several experiments at one time than would a series of reactions in test tubes or test glasses even to a small group. It is the only successful method which the author has found for showing the details of such experiments to large groups of students.

Suppression of ionization of weak acids and bases as indicated by the color change of an indicator or by decreased chemical activity may be shown easily in the lantern. The suppression of ionization of ammonium hydroxide by a soluble ammonium salt with phenolphthalein as an indicator and the suppression of the ionization of acetic acid by a soluble salt of the acid as indicated by the color change of methyl orange may be used for this purpose. A piece of plain white paper instead of the mirror should be placed under the watch crystals containing these materials. A sample of the solution and indicator should be placed by the side of the one in which the suppression of ionization is taking place for reference in comparing the color change of the indicator as the suppression proceeds. The action of acetic acid and of the acid in the presence of one of its soluble salts toward marble can be used to show the effect of suppression of ionization on chemical activity. The difference between ammonium hydroxide

and ammonium hydroxide plus a soluble ammonium salt as precipitants for insoluble hydroxides can also be shown in this connection.

The details of fractional precipitation and fractional dissolving experiments can clearly be shown to large groups by carrying out such experiments in the lantern instead of on the lecture desk. For instance, if silver nitrate solution is added in several separate portions to a mixture of rather dilute solutions of a chloride and a chromate, the white precipitate of the silver chloride first formed will give place to a mixture of white and red precipitates as successive portions of silver nitrate are added to the solutions. Or, on addition of a solution of a chloride to the red precipitate which has been drained free from supernatant liquid, the red silver chromate will be dissolved* and give place to a white precipitate of silver chloride, thus illustrating one of the methods of dissolving insoluble compounds. The dissolving of lead iodide with a solution of an oxalate illustrates the same point. Dissolving through complex ion formation can also be nicely demonstrated by the action of a solution of ammonia on an insoluble cupric salt. To illustrate the principle of fractional dissolving a solution of ammonia can be used on a mixture of silver chloride and silver sulfide.

As a miscellaneous collection of experiments the following are briefly mentioned as suggestive of the range of application of the lantern experiments. The effect of light on silver chloride can be clearly exhibited as the light in the lantern fairly quickly causes the silver chloride to darken. The effect of camphor or soap on the surface tension of water can easily be demonstrated. If a large crystallizing dish containing a small amount of water is placed in the lantern, small bits of gum camphor added to the water, and the image of the whole focused on the screen, the pieces of camphor will dart about over the screen as if they were animate matter. Or, to show the effect of soap on the surface tension of water, add a drop of oleic acid to a dilute solution of ammonia. For demonstrating quickly the double refraction of Iceland spar, use some highly colored object as a colored plate of bright line spectra. A certain line or lines can be shown without the spar and then shown with the crystal of spar lying over the colored lines. As viewed through the crystal each line will appear double. Liesegang rings in silicic acid gel in small test tubes can also, with the aid of the lantern, be shown very nicely to large groups.

A few general points to be borne in mind in setting up the experiments in the lantern are listed below for the convenience of those who wish to use any of the experiments herein mentioned or others which these may suggest:

1—Use watch crystals or low-form crystallizing dishes for experiments.
2—For best results if the materials to be used are somewhat opaque, set

* Obviously, the term *dissolve* as here used refers entirely to chemical reactions and, therefore, is rather inaccurately used in the strictest sense of the term.

the apparatus on a mirror placed in the lantern. However, if the materials are entirely in solution and color changes only are to be noted the best results may be obtained by setting the apparatus on a piece of white porcelain or plain white paper.

3—Because of the heating effect of the lamp in the lantern the light should be turned on only as needed.

4—A dropping pipet of the medicine dropper type, or a longer one, has been found most convenient to use in adding small quantities of liquid to a piece of apparatus already in the lantern.

5—Since three-dimensional objects are to be projected it may be necessary to change the focus of the lantern slightly during the experiment in order to show all of the details of interest.

6—The "layer of reagents" in the pieces of apparatus used should be kept as thin as possible.

The experiments above outlined are mentioned only as examples of classes of experiments which may by means of the lantern easily be shown to large groups. These will doubtless suggest many more to the reader as well as call attention to an additional use for as expensive a piece of apparatus as an opaque projection lantern.

Carbonic Acid Cause of Earth's Ice Age. If the amount of carbonic acid in the air decreased to half of its present amount the temperature would fall enough to cause another great ice age on the earth. Calculations showing this were disclosed to the National Academy of Sciences meeting recently in Washington, by Dr. E. O. Hulburt of the U. S. Naval Research Laboratory.

The small amount of carbon dioxide in the air absorbs much of the heat of the sunlight falling on the earth's surface. A change in the amount of this gas changes markedly the amount of heat retained by the air and therefore the average temperature over the earth's surface. Dr. H. B. Maris, also of the Naval Research Laboratory, originated the new theory.

Dr. Hulburt's work was concerned in the first place with calculating the air temperature to be expected from a knowledge of the kinds and amounts of different gases present in the atmosphere at different heights and from a knowledge of how the various constituents of sunlight are absorbed by these substances. The sea level temperature calculated from Dr. Hulburt's formula comes within one degree of the known average earth temperature. This is taken to mean that emission and absorption of radiation are the only processes concerned in the control of the earth's atmospheric heat on the surface. At higher levels mixing by winds interferes with simple conclusions of the theory.—*Science Service*

Sex Hormone Promises Usefulness in Medicine. Four active substances, probably hormones, have been isolated from the placenta, part of the female reproductive organs, Dr. J. B. Collip of McGill University and one of the famous Toronto group that gave insulin to the world, reported recently to the Association for the Study of Internal Secretion. These substances act as sexual stimulants in both males and females.

One of them is valuable in treating disturbances of the reproductive cycle in females. It is the first preparation of this type which is effective when given by mouth.—*Science Service*

A NOVEL HIGH-SCHOOL EXPERIMENT IN HYDROGENATION OF OILS

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"Unless you have some objection I would like to try to hydrogenate some oil. Everybody works on such topics as soap, paper, ink, perfume, and glass. I'd like to do something different and anyway I want to know more than what we discussed in class about this hydrogenation." Permission to investigate the subject and then attempt an experiment, provided it entailed no danger to himself or his classmates, was gladly granted to the young high-school student who wished to be original.

From reading, the lad learned that such substances as Crisco, Cottolene, Kingnut Margarine, and other butter, lard, or olive oil substitutes were solid fats which had been made from liquid oils containing unsaturated compounds. Olive, oleo, cottonseed, and cocoanut oils contain olein, $(C_{17}H_{33}COO)_3C_3H_5$. Linseed oil contains linolein, $(C_{17}H_{31}COO)_3C_3H_5$, and linolenin, $(C_{17}H_{29}COO)_3C_3H_5$. Cod-liver and manhaden oils contain clupanodonin, $(C_{17}H_{25}COO)_3C_3H_5$. All these oils can be made to absorb hydrogen. The saturated compounds become solid fats suitable for foods or for making soaps. The reaction may be represented as follows:

$$\underset{\text{Linolein}}{(C_{17}H_{31}COO)_3C_3H_5} + 6H_2 \longrightarrow \underset{\text{Stearin}}{(C_{17}H_{35}COO)_3C_3H_5}$$

$$\underset{\text{Olein}}{(C_{17}H_{33}COO)_3C_3H_5} + 3H_2 \longrightarrow \underset{\text{Stearin}}{(C_{17}H_{35}COO)_3C_3H_5}$$

The hydrogen under pressure was blown through oil, heated to about 200°C. in an air-tight vessel. Nickel oxide, or finely divided nickel, suspended in the oil acted as the catalyzer. The more complete the hydrogenation the harder and more brittle the fat becomes, the completely hydrogenated product resembling tallow.

All the information obtained from reading, though interesting, was too indefinite for the high-school student investigator, and he turned from books to manufacturers and advanced students of organic chemistry. His S. O. S. letters brought back mainly discouragement. One company wrote him that hydrogenation of oil on a small scale was not practical. A professor of organic chemistry said it would be difficult to set up an apparatus for the hydrogenation of oil in a school laboratory, and there was no definite printed material on such an experiment as far as he knew. Only one letter held hopes for any success in the undertaking. Although the writer of this letter advised that all experimental work be carried on under the close supervision of the instructor, he expressed great confidence in the ultimate accomplishment of the project even when carried out on a small scale. He suggested preparing a suspension of nickel formate in paraffin and then mixing enough suspension with cottonseed oil so that the oil would contain about 1% nickel.

The experiment was performed as follows: hydrogen was generated in a Kipp generator, passed through a bottle containing about 200 cc. of concentrated sulfuric acid, and then through a calcium chloride tube. The reaction chamber was a liter Florence flask fitted with a four-holed stopper. One hole served as an entrance for the hydrogen delivery tube which extended to the bottom of the flask. From a second hole came a right-angle exit tube connected with a long rubber tube. This led the excess hydrogen away from the flame used in heating the oil. The third opening served for the introduction of a stirrer which later was found to be unnecessary as the continual bubbling of the hydrogen through the material caused sufficient agitation. A thermometer was inserted in the fourth hole. Sixteen grams of nickel formate and 75 cc. of paraffin were placed in the flask. The whole apparatus was flushed with hydrogen and the contents of the flask kept at 240°C. for two hours with a slow stream of hydrogen constantly passing through. The green nickel formate began to turn black when a temperature of 200°C. was reached.

Next day 800 cc. of cottonseed oil were added to the mixture in the flask. The whole was heated to 200°C. Before heating, the hydrogen was run through the apparatus for several minutes. Throughout the experiment it was sent in at a rate great enough to keep the mixture of oil and catalyst constantly and thoroughly stirred. No air was allowed to enter the apparatus. After about one and one-half hours of heating, approximately 20 cc. of the warm liquid was removed, filtered through cotton, and cooled to room temperature. The product formed a soft yellow solid which melted when the test tube was held in the hand. After another half hour the heat was removed and the mixture filtered through cotton. The filtrate when cooled to room temperature this time became a much firmer solid, yellow in color.

Two methods of removing the yellow color were tried. One portion of the melted fat was filtered through activated carbon kept warm in a water-jacketed copper funnel. Another portion was placed in a beaker set in a bowl of ice water and beaten until a creamy product was obtained. The latter produced the better looking fat.

Stanley Baldwin at St. Andrew's University. There is something to be prized more than learning during undergraduate years, for above it must be placed "the constant clash of personality, the interchange of ideas, the questionings, the testing of opinion, the growth of knowledge of human nature, all those things that no books can give and that can only be obtained by that free intercourse which is most natural and most easy in the elastic formative years of undergraduate life." So long as our colleges and universities provide these democracies in little, they may fail here and there in strictly educational theory and practice, but at any rate they are supplying the best kind of training for life and for the active duties of citizenship.—*The New York Times*

THE USE OF ANION GROUP TESTS IN TEACHING QUALITATIVE ANALYSIS*

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Anion group tests may be used to emphasize oxidation-reduction, solubility product, common ion, complex ions, and the ionization of polybasic acids in stages. Also, the group tests serve as a convenient introduction to the study of the anions and in some cases may be used to shorten the procedure necessary to identify the anions.

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A well-known memory course is based on association of newly acquired ideas or facts with those already firmly fixed in the mind. Oxidation-reduction, solubility product, common ion, complex ions, and primary, secondary, and tertiary ionization are mere words to a beginner in chemistry and remain such until chemical reactions involving these are carried out and form a mental picture around which may be built a framework of theoretical principles.

Elementary qualitative analysis affords an excellent opportunity for teaching the fundamental theories on which chemistry is based, and most textbook writers avail themselves of this opportunity. Thus, in the separation of the acid-insoluble and acid-soluble sulfides, in the solution of the alkaline earth carbonates in acetic acid, and numerous other reactions, the solubility product principles is emphasized. At the proper place in the procedures, attention is called to reactions involving each of the above *words*. However, but few writers of qualitative texts make use of group tests for anions as fully as can be done advantageously, both from the standpoint of theory involved and the simplification of laboratory tests. It is the purpose of this paper to call attention to a way in which certain of these group tests may be used for the above purposes.

The group tests given below were chosen on account of their simplicity, their reliability in student hands, and for the chemical principles involved.

Groups of Anions[1]

Group 1.—Anions decolorizing dilute permanganic acid[2] (reducing constituents): arsenite, cyanide, ferricyanide, iodide, nitrite, sulfide, sulfite, thiocyanate, and thiosulfate, without warming. Bromide, oxalate, and tartrate give the test when warmed.

* Presented before the Division of Chemical Education at the 81st meeting of the A. C. S., Indianapolis, Indiana, March 31, 1931.

[1] In this article, the following anions are considered, although not all of them give positive group tests: acetate, arsenate, arsenite, borate, bromide, carbonate, chlorate, chloride, chromate, cyanide, ferricyanide, ferrocyanide, fluoride, fluosilicate, hypochlorite, iodide, nitrate, nitrite, oxalate, phosphate, sulfate, sulfide, sulfite, tartrate, thiocyanate, and thiosulfate. Bieskey (*1*), using the same reagents as are used in this paper, classified nitrate and chlorate as oxidizing constituents. However, a nega-

Group 2.—Anions liberating iodine from very dilute hydriodic[3] acid (oxidizing constituents): arsenate, chromate, ferricyanide, hypochlorite, and nitrite.

Group 3.—Anions with silver nitrate forming precipitates insoluble in dilute nitric acid: bromide, chloride, cyanide, ferricyanide, ferrocyanide, iodide, sulfide, thiocyanate, and thiosulfate (the latter, on decomposition of its silver salt).

Group 4.—Anions with silver nitrate forming precipitates insoluble in $4N$ ammonium hydroxide: ferrocyanide, iodide, and sulfide.

Group 5.—Anions with silver nitrate forming precipitates soluble in $2N$ ammonium hydroxide, but insoluble in dilute nitric acid: bromide, chloride, cyanide, ferricyanide, thiocyanate, and thiosulfate.

Group 6.—Anions forming stable acids and with silver nitrate forming precipitates in neutral solution, but not in dilute nitric acid or dilute ammonium hydroxide solution: arsenate, arsenite, chromate, oxalate, and phosphate.

For a group test to be of value in the identification of anions, it must be given by every member of the group, even in very low concentrations, and must not be given by other substances. In this laboratory, it has been found that these group tests in most cases are more sensitive than individual tests for the anions (see Table 1), and anions not in the groups, with five exceptions[4] do not interfere when present in concentrations as high as

tive test for oxidizing constituents does not mean that these ions are absent, or even not present in fairly high concentrations. This is true particularly of nitrate, for under the experimental conditions used in this laboratory (detailed instructions will be sent gratis to any one requesting them) 25 mg. of nitrate per cc. give a negative test. By using a higher concentration of hydriodic acid, the tests for nitrate and chlorate, as well as arsenate, become more delicate. Also, the possibility of obtaining a positive test by atmospheric oxidation of or by decomposition of hydriodic acid becomes much greater.

[2] The permanganate solution was $0.05N$ in sulfuric acid and contained enough permanganate that dilution of a sample with an equal volume of water left a distinct color. 250 cc. of the permanganate solution were reduced by 0.38 cc. of $0.1050N$ ferrous sulfate solution. Equal quantities of anion solution and permanganate solution were used in the tests.

[3] The iodide solution used was $0.25N$ in potassium iodide and $0.05N$ in sulfuric acid and contained 1 per cent of starch. 3 cc. of this solution were used with 5 cc. of the anion solution.

[4] Prolonged heating, low concentration of permanganate, and high concentration of acid or ferricyanide favor the interference of the latter in Group 1. However, if it is present in high enough concentration to give a test, usually its color will be strong enough to indicate its presence. Bromide and thiocyanate interfere in Group 4, if present in much greater concentrations than 14 and 16 milligrams, respectively, per cc. Oxalate precipitates in Group 5, if the concentration is appreciably greater than 10 milligrams per cc. Chlorate oxidizes hydriodic acid to free iodine under the experimental conditions, if chlorate is present in concentrations as great as one milligram per cc.

25 mg. per cc. As is evident from the table, in four out of forty positive tests, it is necessary to have from 0.12 to 0.20 mg. of anion per cc., but usually the amount needed for a test is between 0.001 and 0.05 mg. per cc.

Frequently, by the use of the anion group tests, many anions are eliminated, so the time required to analyze the solution is shortened materially.

TABLE I

Group Tests*

(*Amount necessary to give positive test expressed in mg. of anion per cc. of solution*)

Groups	*1*	*2*	*3*	*4*	*5*	*6*
Arsenate		0.10[b]				0.01
Arsenite	0.05					0.01
Bromide	0.02[a]		0.02		0.02	
Chloride			0.05		0.05	
Chromate		0.001				0.01
Cyanide	0.2		0.05		0.10	
Ferricyanide		0.01[b]	0.20		0.10	
Ferrocyanide	0.12		0.10	0.10		
Hypochlorite		0.002	Cl-interferes		Cl-interferes	
Iodide	0.02		0.01	0.04		
Nitrite	0.07	0.002				
Oxalate	0.07[a]					0.01
Phosphate						0.20
Sulfide	0.02		0.02	0.05		
Sulfite	0.07					
Tartrate	0.07[a]					
Thiocyanate	0.01		0.02		0.02	
Thiosulfate	0.03		0.05		0.05	

Anions not in groups: acetate, borate, carbonate, chlorate, fluoride, fluosilicate, nitrate, and sulfate.

* The sensitivity of each test was worked out carefully by two students, Gerald Leslie and W. T. Forsee.

[a] Heated.

[b] Heated and cooled. In case of doubt, let stand several minutes.

Use of Group Tests to Illustrate Chemical Principles

In an experiment involving color change, the student readily recognizes that a chemical change has taken place, and the more noticeable the color change, the more vividly is the experiment impressed on his mind. Actual treatment of an acid solution of potassium permanganate with each of the twelve reducing constituents, writing of equations for reactions taking place, and the testing of unknowns for reducing constituents teaches an alert student more about reducing constituents than the average student learns in the entire course in qualitative. Similarly, the formation of the deep blue of starch-iodine solution affords a mental picture which assists in remembering oxidation reactions.

An unusual opportunity for the discussion of solubility product, common ion, complex ions, and the ionization of polybasic acids in stages is given in the study of the groups of anions which precipitate with silver nitrate in acid solution, which precipitate in ammonia solution, which precipitate in acid but not in ammonia solution, and which precipitate in neutral but not in either acid or ammoniacal solution. The adjustment of the conditions in the solution, so as to test for each of these groups of silver salts, the writing of the equations for the reactions involved, and the explanation of the observed phenomena, in the light of the *words* at the beginning of the paragraph, all serve to impress important chemical principles on the mind of the student.

Last, but not least, the anion group tests help the student get acquainted with the anions and their reactions. Almost every one of the metals forming the cations studied in elementary qualitative analysis is familiar to the student, either as a free element, or in some compound associated with his every-day life. The same is not true of the anions. Such words as ferrocyanide, ferricyanide, thiosulfate, and tartrate usually mean very little to the qualitative student when he starts his anion procedures. The lack of system in these procedures usually adds to his bewilderment. Likely the carrying out of any reactions of the anions would serve to introduce the student to these more or less unfamiliar radicals, but it is our opinion that this can be done more easily with a few group reactions than with a much larger number of individual reactions. After the student becomes acquainted with the anions, and some of their group reactions, it becomes easier for him to learn specific tests for each anion, particularly if these tests are based on some anion group tests, as many are.

Literature Cited

(1) BIESKEY, *Chem. Rundschau Mettleuropia Balkan*, **2**, 105–7, 119–23 (1925).

A New Industrial Chemical, Anhydrous Hydrofluoric Acid. Commercial hydrofluoric acid has in the past always contained from 70 to 40% water, and is best known as one of the few chemicals that will attack glass, so that it cannot be kept in glass bottles. Recently the first tank car of anhydrous hydrofluoric acid was shipped by the producers of this new industrial chemical, Sterling Products Company of Easton, Pennsylvania. The anhydrous acid, which is made from fluorspar and sulfuric acid, boils at 19°C., has a specific gravity approximately the same as that of water, and can be shipped in steel containers; it has a great affinity for water, will char a piece of wood, and is very destructive to rubber. At present it finds its chief use in the manufacture of difluorodichloromethane, the new refrigerant, the advent of which we mentioned in our issue of May, 1930. Availability of the anhydrous acid will probably lead to its employment in connection with other processes.—*Ind. Bull., Arthur D. Little, Inc.*

QUANTITATIVE EXPERIMENTS IN ELEMENTARY CHEMISTRY. I. DETERMINATION OF THE MOLECULAR WEIGHT OF OXYGEN

R. D. Billinger and W. W. Williams, Lehigh University, Bethlehem, Pennsylvania

The standard method of determining the molecular weight of oxygen by heating potassium chlorate is criticized. A method utilizing sodium peroxide and water is outlined. Comparative results of tests on both methods are given.

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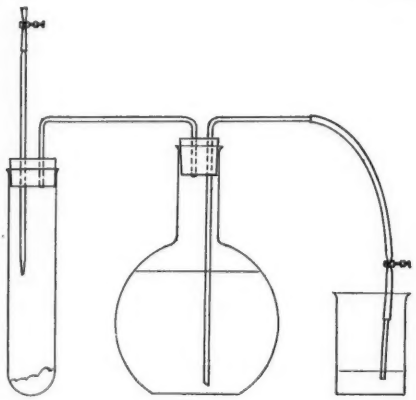
The standard experiment of determining the molecular weight of oxygen in general chemistry laboratory courses invariably utilizes potassium chlorate as the source of oxygen. While the method in principle is good, there are certain inherent difficulties which are often the source of trouble to a freshman.



In the first place the potassium chlorate should be dried, which is usually neglected or incompletely done. The experiment also requires a hard glass test tube, sufficient numbers of which are not always available for large classes. The heating of the chlorate requires the most attention, because if impure or if suddenly heated to a high temperature, the salt may detonate. There is also occasional trouble with sublimation of the potassium chloride formed.

With a view to shortening the experiment and obviating the above difficulties it was decided to use sodium peroxide as the source of oxygen. Details of the experiment follow.

Assemble the apparatus shown in the accompanying diagram. The following will be required: a 5-cc. graduated pipet, a 7-inch test tube, a 500-cc. flask, a 400-cc. beaker, 1 foot of rubber tubing, 2 feet of glass tubing for connections, 2 pinchclamps, and a thermometer.

Draw water up into the pipet and then tighten pinchclamp to hold water at upper limit of graduations. Place about 1.5 g. of sodium peroxide in the dry test tube, carefully transferring the material by means of a clean, dry, porcelain spoon. Stopper the tube with a cork and then weigh it accurately. The tube may readily be suspended on the balance arm by means of a wire ring and hook.

When ready to start the experiment, fill the flask to the neck with water. Also fill the siphon tube with water, by sucking water into the tube and then closing the pinchclamp. Adjust conditions so that the air in the flask is under atmospheric pressure. This is done by placing a small beaker of water under the delivery tube, opening the pinchclamp and raising the beaker until the level of water in the flask is the same as that in the beaker. Now tighten the pinchclamp and place a dry 400-cc. beaker under the delivery tube. Connect the weighed test tube to the apparatus and see that all joints are tight. Open the pinchclamp controlling the delivery tube, and almost immediately begin the generation of oxygen by allowing water to drop slowly from the pipet. Control the addition of water to the test tube, so that no oxygen escapes by way of the pipet. Considerable pressure is developed and a volume of water equal to the oxygen liberated is forced from the flask into the beaker.

After the action has slowed up add several more cc. of water from the pipet into the test tube. Record the volume of water added.* Allow the tube to cool to room temperature (explain the increase in temperature in the tube) and then weigh as at the beginning of the experiment. The first weight, plus the weight of water added, minus the last weight represents the weight of the oxygen evolved. Remove the beaker of water, after first adjusting the levels for atmospheric pressure in the flask. The volume of water may be obtained by weighing the beaker plus water on a platform scale, and then subtracting the weight of the dry beaker. If a large graduate is available, the volume can be more quickly measured directly. Record the temperature of the water and also obtain the atmospheric pressure from a barometer. Enter all data in your notebook and then calculate (1) the weight of a liter of oxygen and (2) the molecular weight of oxygen.

Data

(*a*)	Weight of test tube plus sodium peroxide plus cork	=
(*b*)	Weight of water added	=
(*c*)	Weight of test tube plus cork (after reaction)	=
(*d*)	Weight of oxygen evolved ($a + b - c$)	=
(*e*)	Weight of beaker plus water	=
(*f*)	Weight of beaker	=
(*g*)	Volume of water = volume of oxygen	=
(*h*)	Temperature	=
(*i*)	Barometric pressure	=
(*j*)	Aqueous tension at temperature of experiment	=
(*k*)	Volume of oxygen at 0°C. and 760 mm.	=
(*l*)	Weight of 1 liter of oxygen at standard conditions	=
(*m*)	Molecular weight of oxygen	=

* The weight of water added can be assumed very nearly equal to the volume of water dropped from the pipet. However, greater accuracy can be obtained by previously calibrating the weight-volume relation of the pipet.

The following data are submitted to show the relative merits of this method as compared to the chlorate method. Two groups of students were selected at random from the elementary laboratory. One group of nine students was required to determine the weight of a liter of oxygen by heating potassium chlorate (the standard method). The results were as follows: 1.46, 1.32, 1.38, 1.18, 1.48, 1.43, 1.45, 1.54, and 1.31, showing an average value of 1.39.

The second group of seven students, who really had less experience with quantitative experiments than the first group, was required to use the sodium peroxide method as outlined above. The values obtained for the weight of a liter of oxygen were: 1.44, 1.40, 1.43, 1.39, 1.43, 1.47, 1.44, the average being 1.43.

Viosterol Found Beneficial to Radium-Poisoning Victims. Almost simultaneously with the news of the twentieth death from radium poisoning among the unfortunate watch factory workers, comes the announcement of a promising method of treating the condition. Viosterol, now often given children in place of cod-liver oil to prevent or cure rickets, has benefited a number of victims of radium poisoning, Dr. Frederick B. Flinn of Columbia University reported recently to the American Medical Association.

Dr. Flinn does not consider that he has a cure for the condition, but merely reports a method of treatment that has given promising results.

"Our experience so far suggests a method of treatment that will eliminate radium salts from the organism as well as improve the condition of the bones if continued for sufficient time," he stated. "It is a matter of months and not days. Care should be taken that fresh preparations are used," he cautioned.

Most conspicuous among radium-poisoning victims were the dial painters in the watch factory who used to put their radium-paint brushes in their mouths to point them. In this way radium got into their bodies and in about one-fifth of them the radium was deposited in the bones instead of being eliminated from the body. While the amounts of radium absorbed in this way were small, the activity of radium is so great that these small amounts were sufficient to destroy bones and tissues and to cause fatal illness.

How to get the radium out of the body before it had caused irreparable destruction was the problem which Dr. Flinn and other scientists attempted to solve. Because radium is related to calcium, it was supposed that any treatment that would affect calcium might have a similar action on the radium deposits, Dr. Flinn explained. So he first tried treatment with an extract of the parathyroid glands. These small glands, located behind the thyroid in the neck, are thought to regulate the calcium of the body.

Parathyroid treatment had been moderately successful, when Dr. Flinn suggested the use of viosterol. Vitamin D, calcium utilization in the body, bone formation, and the parathyroid glands are all linked together, so viosterol, which is a potent source of vitamin D, was a logical selection.

The results of this treatment in eight cases have been good. In two cases, radium was completely eliminated from the body, in the other six, the amount of radium was materially reduced. Improvement in general health, such as freedom from pain, gain in weight and improved condition of the blood, followed the treatment, and one of the patients was able to resume her former housekeeping activities. In most of the patients the destruction of bone was checked.—*Science Service*

CHEMICAL APPARATUS AND SUPPLY SERVICE*

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This article contains a discussion of locker and laboratory supplies, dealing with purchasing and selling of chemicals and apparatus in colleges; a method for checking into and checking out of student lockers; also notes on dispensing, accounting, and personnel.

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Having received numerous requests concerning the management and operation of a chemical supply system, the one in use at the University of Pittsburgh is here briefly outlined. Let us consider problems inside the stock rooms and from the consumer's or student's standpoint.

First, we will take the inside because we must have stock before we can sell it. Starting with two empty storerooms of 500 shelves each, and 1500 student lockers divided as follows—800 inorganic, 400 organic, 150 analytical, 35 physical, 25 food and graduate research, etc.—we proceed to do some buying to stock these lockers and storerooms. The lockers are equipped for the specific courses as follows:

Inorganic Chemistry

Non-Returnables

1 Blow Pipe	1 m. Rubber Tubing, 6 mm.
2 Rubber Stoppers (2-holed) (1 No. 6, 1 No. 7)	1 m. Rubber Tubing, 4 mm.
	Filter Papers, 11 cm.
1 File, Triangular	1 box Matches
1 Test-Tube Brush	1 Cloth
1 Funnel Brush	1 Sponge
1 Test-Tube Holder	1 box Labels
1 pc. Charcoal	1 Scratch Pad
1 pr. Tweezers	1 Wire Gauze
1 Crucible and Lid	1 Burner
1 Triangle	1 Rubber Policeman
1 Pinchcock	1 pr. Goggles
1 pc. Asbestos	1 Rule
2 lengths Glass Tubing, 6 mm.	2 Burner Tips
2 lengths Glass Rod	1 Porcelain Boat

Returnable Apparatus

2 Hard-Glass Test Tubes, 150 × 15 mm.	2 Bottles, wide mouthed, 60 cc.
1 Hard-Glass Test Tube, 200 × 25 mm.	1 Drying Tube
1 Measuring Cylinder, 25 cc.	3 Glass Plates, 75 mm.
2 Buret Clamps	1 Thistle Tube
1 Mortar and Pestle, 75 mm.	4 Watch Glasses
1 Porcelain Dish, 145 mm.	1 Combustion Tube
1 Porcelain Dish, 60 mm.	1 Rack Containing 12 Test Tubes
4 Erlenmeyer Flasks, 1—150 cc., 2—300 cc., 1—500 cc.	6 Beakers, 2—100 cc., 2—200 cc., 2—300 cc.
	2 Funnels, Long Stem, 75 mm.
1 Florence Flask, 500 cc.	1 Iron Stand
4 Bottles, wide mouthed, 250 cc.	2 Rings, 1—150 mm., 1—75 mm.

*Contribution No. 211, Department of Chemistry, University of Pittsburgh.

Organic Chemistry

Non-Returnable Chemicals and Materials

50 g. Calcium Acetate
225 g. Calcium Chloride
20 g. Dextrose
40 g. Iodine
40 g. Phenol
30 g. Potassium Hydroxide
180 g. Sodium Acetate, Fused
40 g. Sodium Nitrite
Towel
Asbestos Square
Scratch Pad
Labels
Goggles
Sponge
Triangle
File, Triangular
Crucible
Wing Top
Rat Tail File
1 can Chlorinated Lime
90 cc. Acetone
120 cc. Benzene
90 cc. Formaldehyde, 40% Soln.
120 cc. Acetic Acid, 99%
60 cc. Methyl Alcohol
60 cc. Formic Acid
Corks, Assorted
Copper Wire, Band No. 18
Rubber Tubing, 4 lengths
Filter Paper, 11 cm.
Wire Gauze
Glass Tubing, 6 mm.
Glass Rod
Test-Tube Brush
Litmus Paper
Matches
Crucible Lid
Cork Borers
1 Burner

Returnable Apparatus

2 Buret Clamps
2 Condenser Clamps with Fasteners
2 Condensers
4 Distilling Flasks—30 cc., 100 cc., 200 cc., 500 cc.
2 Funnels, 65 mm., 100 mm.
1 Separatory Funnel, 60 cc.
2 Thermometers, 200°C., 360°C. (with wooden cases)
1 Agate Pan
1 Iron Chimney
2 Rings, 60 mm. and 120 mm.
1 Tripod
1 Sand Bath
1 Suction Flask, 1000 cc.
1 Bottle, rubber stopper, 250 cc.
6 Beakers, 50, 100, 200, 300, 500, and 1000 cc.
6 Erlenmeyer Flasks, 2—150 cc., 2—300 cc., 2—500 cc.
1 Oil Bath
1 Drying Tube, 15 cm.
1 Distilling Flask, Low Side Arm, 200 cc.
1 Water Bath, with rings
1 Flask, R.B.S.N., 1000 cc.
4 Bottles, wide mouthed, 250 cc.
1 Mortar and Pestle, 125 mm.
3 Clock Glasses, 75 mm., 100 mm., 150 mm.
3 Watch Glasses
2 Porcelain Dishes, 60 and 145 mm.
1 Porcelain Spatula
2 Measuring Cylinders, 10 cc. and 100 cc.
1 Hard-Glass Test Tube, 20 cm.
3 Bottles, G.S., 250 cc.
12 Test Tubes in a Rack
1 Air Condenser
2 Round-Bottomed Flasks, 100 cc. and 500 cc.
1 Büchner Funnel, 80 mm.
4 Glass Plates

Analytical Chemistry

First Semester—Non-Returnable Outfit

1 tube Litmus Paper
1 Sponge
1 Towel
1 box Matches

1 length Rubber Tubing, 6 mm.
1 ft. Rubber Tubing, 4 mm.
1 Thistle Tube
1 Pinchcock
1 Triangular File
1 125 cc. wide-mouthed Bottle
1 box Labels
1 Asbestos Pad
1 Wire Gauze
1 pkg. Filter Paper
1 length Glass Tubing
3 Stirring Rods, 20 cm. each
1 2-holed Rubber Stopper to fit 125-cc. bottle
1 2-holed Rubber Stopper to fit Erlenmeyer Flask
1 2-holed Rubber Stopper to fit Florence Flask

Second Semester---Non-Returnable Outfit

1 tube Litmus Paper
1 Towel
1 box Matches
1 length Rubber Tubing
1 Rubber for Gooch Filter
3 Stirring Rods
2 Wire Gauzes
2 Porcelain Triangles
3 Porcelain Crucibles with Lids
2 Pinchcocks
3 Policemen
1 pr. Crucible Tongs

Gooch Crucibles are to be bought at stockroom, and are returnable at end of semester if in good condition (not marked).

Returnable Apparatus

2 Measuring Cylinders, 10 and 100 cc.
2 Pipets, 10 and 50 cc.
4 Clock Glasses, 2—75 and 2—150 mm.
4 Watch Glasses
4 Porcelain Dishes, 2—60 mm. and 2—145 mm.
7 Beakers, 2—200, 2—400, 2—500, and 1—1000 cc.
1 Double, or 2 Single, Buret Clamps
4 Iron Rings
1 Desiccator, 125 mm.
2 Measuring Flasks, 500 and 1000 cc.
5 Bottles, glass-stoppered, 1000 cc.
8 Bottles, glass-stoppered, 250 cc.
2 Mohr Burets, 50 cc.
2 Weighing Bottles
1 Filter Tube
1 Spot Plate
24 Test Tubes in Rack
8 Erlenmeyer Flasks, 2—125, 4—300, 2—500 cc.
5 Funnels, 2—65, 2—75, and 1—100 mm.
1 Florence Flask, 500 cc.
2 Burner Tips
2 Filter Stands
1 Mortar and Pestle
1 Bottle, 500 cc., wide mouthed, glass-stoppered
2 Iron Stands
1 Suction Flask, 1000 cc.

Physical Chemistry

Returnable Apparatus

1 Thermometer, 110°C.
1 Clamp
1 Extension Holder
2 Supports, medium base
1 Condenser, Liebig
3 Rings, Iron, 50, 75, 100 mm.
1 Beaker, 50 cc.
2 Beakers, 200 cc.
2 Clamps, Universal, small
2 Clamp Holders
1 Clamp, Buret
2 Burners, Bunsen
1 Measuring Cylinder, 100 cc.
3 Bottles, g.s., 250 cc.
2 Bottles, g.s., 1000 cc.
1 Beaker, 3000 cc.

Sanitary Chemistry

Returnable Apparatus

2 Buret Clamps
2 Condenser Clamps with fasteners
1 Wing Top
2 Thermometers, 200 and 360°C.
3 Clock Glasses, 75, 100, 150 mm.
3 Watch Glasses
2 Porcelain Dishes, 60 and 145 mm.
1 Porcelain Spatula
3 Test Tubes, 20 cm. Pyrex
2 Mohr Burets, 50 cc.
1 Agate Pan
1 Iron Chimney
4 Rings, 2—60 and 2—120 mm.
1 Tripod
1 Suction Flask, 1000 cc.
1 Bottle, 250 cc., rubber stopper
8 Beakers, 2—50, 2—100, 1—200, 1—300, 1—500, and 1—1000 cc.
12 Test Tubes in a Rack
1 Funnel Rack
2 Flasks, Distilling 50 and 500 cc.
3 Funnels, 35, 65, and 100 mm.
1 Hot Water Funnel
1 Separatory Funnel, 125 cc.
2 Porcelain Crucibles with covers
2 Graduated Cylinders, 25 and 100 cc.
1 Carbon Filter Tube
5 Pipets, 1, 5, 10, 25, and 50 cc.
1 Pipet, Graduated, 10 cc. in 0.01
4 Weighing Bottles
2 Flasks, 300 cc.
4 Flasks, Measuring, 50–55, 100–110, 500 cc., and 1000 cc.
2 Desiccators, 125 mm.
6 Bottles, g.s., 250 cc.
1 Sand Bath
2 Babcock Milk Bottles
2 Water Baths, 125 mm.
2 Condensers, 30 cm.
2 Iodine Flasks
6 Erlenmeyer Flasks, 2—150, 3—300, 2—500 cc.
1 Flask, R.B.S.N., 1000 cc.

After the lockers have been stocked, each is locked with a padlock and the keys are placed inside the locker. These padlocks with two thousand key changes operate on a single master key. The master keys can be changed every two or three years.

Stockrooms must be provided with all the chemicals and apparatus necessary to supply all courses, lecture demonstrations, etc., during the year. This must be done carefully to avoid dead stock, and prevent purchase of materials already in stock. Supplies are classified as inorganic chemicals, organic chemicals, and apparatus, all of which are listed on a Kardex filing system which contains the name of the article, the price, and the shelf on which it is placed. Surplus and dangerous chemicals are stored in an outside fireproof vault, while glassware in cases is kept in storage.

When a university has a central purchasing department, great savings can be made by buying on a competitive basis. Supplies are ordered on specification and will not be accepted if not up to standard. In the purchase of large quantities of glassware, a considerable amount is saved by pooling the orders of the different departments. Bulk chemicals and routine supplies for the entire year are purchased in a single lot. Special chemicals and unusual supplies are bought in small quantities as needed, rather than in larger quantities and carried as inventory. Discarded special apparatus is returned and stored for future needs. Frequent requests are received for units from this stock.

A further saving to the student who buys chemicals in 10- or 20-gram lots, is made by our buying these in bulk and selling the small amounts at the large lot prices. A study of the cost of supplies in small cartons prepared by the stockroom as against the cost of ready-made packages shows a savings of one-half.

The average course cost per student for chemicals and apparatus including breakage, under this system, rarely exceeds $15.

Sales

Each storeroom is supplied with a cash register. Fee cards of $5 each, similar to a meal ticket, are sold to the students at registration, by the University Treasurer, and the amount of each purchase is punched at the time of purchase. This is rung up as cash sales. Material returned by the students is paid for in aluminum credit coins by the storeroom and is rung up on the "Paid Out" key of the register. Charge and credit slips are used only by the faculty.

Checking into Lockers

Now we are ready to open courses. The classes have been met by their teachers and instructed as to procedure. They form in line at the supply room and present their fee cards from which are punched the cost of the non-returnable apparatus, padlock, and chemicals which are already in their lockers. At the same time, they make their breakage deposit which may be one or two $5 cards, for which they are given receipts. These are a deposit against non-returnable locker contents. Students now go to the instructor, show their receipts, and are assigned lockers. These lockers are opened by the instructor with a master key and the students proceed to check the contents of the locker. Any shortage, breakage, or dirty apparatus is listed by the student on a "Shortage Card" which is in the locker. The shortage is checked by the instructor who signs the card, and upon presentation at the supply room, the student receives the listed articles without charge. In other words, the student must have a complete outfit of good apparatus and he does not have to accept any material that, in his opinion, will not be acceptable when he checks out.

Checking Out of Lockers

At the end of the year, the student must check out his locker or forfeit his deposit. This checking out is done by separating the non-returnable material from the returnable. The former, including the padlock, is the property of the student. The returnable material is cleaned by the student. All broken, damaged, or rejected material is replaced by purchase at the stockroom. The locker is then checked by the instructor who locks it with a new padlock, placing the keys inside the drawer. The locker

is now ready for the next student. Students continuing chemistry may use their old padlocks instead of purchasing a new one for each course.

Dispensing

In inorganic chemistry, all solid chemicals are put up in individual coin bags on which is stamped the name of the contents. Liquid reagents are placed on shelves along the wall. Every precaution is taken to insure a student getting the correct chemicals and to prevent his experimenting with wrong or dangerous ones. No student is permitted to perform any experiment except the one assigned. In fact, he does not have anything with which to perform it and cannot therefore engage in dangerous experiments. He must protect his eyes with goggles. Showers and blankets are provided in case his clothes catch fire. First-aid cabinets are available and every locker contains a sheet of first-aid instructions.

In organic chemistry, each locker contains part of the chemicals used for experimenting, and the remainder (where containers would cost more than the materials), together with test solutions, and milk, eggs, lard, butter, apples, etc., which are perishable, are placed on shelves around the room. Balances and rolls of wrapping paper, on which the weighing can be done, are also provided on these shelves. These supplies are charged to the class and each student pays his pro rata share on checking out. Analytical, food, and physical chemistry are handled in the same way.

The graduate research student has a table space and locker assigned, after depositing two cards. The lockers are empty, and each student draws out the necessary material by signing a charge slip at the stockroom on receipt of same. When he has completed his work, all materials which can be used again are returned to the stockroom and listed on a "credit" slip. The difference between the charges and the credits is paid for by the student, by punching the amount on his cards. Additional cards must be deposited as required.

Personnel

The personnel of the stockroom consists of the custodian of supplies and three full-time assistants. Two assistants take care of one stockroom which supplies the inorganic and organic laboratories, while the other assistant and the custodian care for the analytical, physical, food, advanced organic, microscopy courses, research, and lecture demonstration. All the buying, receiving, and accounting for the department is done by the custodian of supplies. All purchases are by approval of the head of the department.

Accounting

The entire aim is to have as little bookkeeping as possible. A brief checkup shows that materials can only be taken from the supply room in

two ways. (1) By cash payment which is rung up at the time of sale. (2) By charge slips (faculty, or course supplies) which are filed alphabetically. The sum of cash sales and charges gives us total sales.

Let us say that we are given $15,000 at the beginning of the year for the maintenance of the supply room and that we have an inventory of $35,000 in stock and locker contents. This gives us a total of $50,000 to start the year. At the end of the year we have an inventory of $30,000, cash sales of $15,000, and charges to research, lectures, and faculty of $5000. This also totals $50,000, and puts our account in balance, *viz.:*

Inventory, July 1, 1929	$35,000	Inventory, July 1, 1930	$30,000
Drawing Account	15,000	Cash Sales	15,000
		Accounts receivable (charge slips)	5,000
Total	$50,000	Total	$50,000

The entire maintenance budget is divided into three parts:

1. Supply Room Maintenance, to which only materials sold for cash are charged.

2. Laboratory Maintenance, to which all repairs to laboratories, stationery, lecture material and anything which cannot be charged to Supply Room Maintenance or Equipment, are charged. The item of $5000 in the preceding balance sheet is transferred to Laboratory Maintenance at the end of the year.

3. Equipment, to which all permanent equipment, as office furniture, microscopes, and the like, are charged.

It is hoped that this article will be of interest to those who have requested the information. Details are lacking, but interested parties may receive further information by writing for it.

Small Families Have Superior Children. The only child is above average in intelligence, in moral knowledge, cultural background, and honesty. He is just average in coöperativeness and persistence; but below average in self-control and in popularity as indicated by ratings made by his teacher and classmates.

This characterization of the child who has no brothers or sisters was made by Dr. Julius B. Maller of Columbia University in a report published in the scientific publication, *The Journal of Social Psychology*. Dr. Maller has been making a study of the relationship between size of family and personality of the children based on data gathered in connection with the Character Education Inquiry at Teachers' College.

Children in families having from two to five offspring Dr. Maller found to be superior in both moral and intellectual characteristics to those born into larger family circles.

"The children of small families are highest in intelligence, in honesty, in inhibition, and in ratings by teacher and classmates," Dr. Maller concluded.

"The children of large families are lowest in intelligence, moral knowledge, cultural background, honesty, coöperativeness, inhibition, parents' intelligence, and moral knowledge. They are highest in scores of persistence."—*Science Service*

Chemical Digest

A REAL ADVANCE IN PEDAGOGICS*

The science of teaching, as a real science, is still in its swaddling clothes. For centuries, pedagogics has been among the most reactionary of professions and little real, basic progress has been made, in this country at least, in the past hundred years. Individual institutions and teachers have, to be sure, experimented with new ideas here and there, but the fundamental features of the system have remained practically as they were at the close of the Civil War. In fact, leading educators admit that the general methods now in vogue have not been modified since universities were first established in America and realize that these methods are very far from meeting modern needs.

A couple of years ago the University of Chicago embarked upon an almost unprecedented experiment by choosing a keen and capable *youngster*, Robert Maynard Hutchins, as its president. This new wine, put into the old bottle, has been fermenting, and next autumn something is going to pop out on the Midway.

Simultaneously or thereabouts, the authorities of Yale University saw gleams of light which convinced them that a human being is not merely a set of more or less highly specialized and unrelated powers and abilities, but a coördinated organism functioning as a unit. From this recognition originated the Institute of Human Relations, about which more information will appear in these pages presently. For the present it is enough to say that the Institute is already fostering a number of the features of the "Chicago Plan." Others, of which we have not heard, may be doing the same thing.

Very briefly, this revolution in pedagogics aims to make the system of instruction fit the student, instead of the archaic plan of hacking and hewing the student to fit the curriculum. It embodies a change from a system, built around "good" and "poor" students, to one based upon "fast" and "slow" students.

Under the old scheme, the student entered into a competitive game with the faculty. No matter what kind of a worker he was, he must spend a certain number of months in the university and accumulate a certain number of "credits" before he could receive his degree.

The professors, as their part of the game, undertook to do their best, by means of daily roll calls and frequent "tests" and examinations, to see that the student was physically present at the class and possessed enough information or cleverness to answer their set questions with sufficient accuracy to receive a certain minimum rating.

On his side, the student undertook, by an astonishing variety of subterfuges, to outwit his instructors in every possible way and to obtain his minimum of "credits" with an irreducible minimum of effort and interference with the real business of attendance at an institution of higher learning—that of making collegiate whoopee.

Of course there were outstanding exceptions to this rule, but the fact

* Editorial, *Clinical Med. & Surgery*, **38**, 466–7 (July, 1931).

that it was decidedly general in its practical application is abundantly demonstrated by the abysmal ignorance of things of vital importance, shown by an appalling percentage of college graduates, except those of the technical schools which have always enrolled considerable numbers of earnest young people with a real purpose in life.

The whole system was adjusted to fit the rate at which the least-interested and most poorly prepared student could be *forced* to progress with his studies. Thus the superior students, in energy and ability, were held back and penalized.

The details of the reorganization of the University of Chicago will be of general interest only to those who are looking for a place where the education of young people can be effectively started, and can be obtained by writing to that institution. The general plan should be widely understood.

The new idea is to give the superior and the earnest student a premium on these qualities, by removing all or most of the restrictions which are required in the grade schools, knocking out the partitions between many of the departments, and saying to the seeker, "Here we have a vast opportunity for you to gain knowledge and culture in general and special lines. Come and take what you want for your purposes. We will do all we can to help you in making a wise choice. Having chosen, proceed as fast or as slowly as your desires urge or your ability permits. When you think you have reached your goal, we will ascertain whether or not you are correct."

Under this system it is assumed that the university student is an adult human being with a purpose. Roll calls, formal "tests," and other measures fit for children are eliminated. The student himself is responsible to himself for his attendance at lectures and classes and for the method and amount of his studying. He can take vacations (or not), when, as, and if he chooses. When he feels that he has a real knowledge of some subject, he announces that fact to the authorities and is given an inclusive and searching examination upon it. If he fails, he fails on two counts: his information was inadequate and his judgment was poor.

From a practical standpoint, an arrangement like this will permit an exceptionally capable young man or woman to finish, for example, the medical course of study in three, or even in two years, instead of the customary four. The opening of doors between departments will tend to develop better all-around, cultured human beings than have been produced under the old methods.

If this and similar experiments now in progress prove successful, all of our universities will have to adopt the plan, or the serious students will be concentrated in those which do so, while the others will be a refuge for the loafers and wasters and those who go to college in order to escape from the realities of life for four more years.

SOME NOTABLE WOMEN OF SCIENCE*

A century ago, on June 27, 1831, the eminent French woman mathematician, SOPHIE GERMAIN, died in Paris at the age of fifty-five years,

* By E. C. SMITH, *Nature*, **127**, 976–7 (June 27, 1931).

and a few days later was buried in the Père Lachaise cemetery. Her great women contemporaries were MARY SOMERVILLE (1780–1872) and CAROLINE HERSCHEL (1750–1848), to whose names might be added, perhaps, that of MRS. MARCET (1769–1858), whose "Conversations on Chemistry" was the means of awakening the interest of Faraday in science. Of the careers of Caroline Herschel, the devoted assistant of Sir William Herschel, and of Mrs. Somerville, whose "Mechanism of the Heavens" and "The Connexion of the Physical Sciences" gave her a world-wide reputation, every one has heard, but Sophie Germain's story is little known. Yet she and Mrs. Somerville had much in common, and their minds were cast in the same mould. When Mary Somerville, amidst the duties of her London home, was finding time to study the works of Lacroix, Biot, Euler, and Laplace, Sophie Germain was corresponding with Lagrange and Gauss, investigating the motion of the sand on Chladni's vibrating plates, and writing memoirs which gained for her the respect and admiration of both mathematicians and physicists. Her place in history is that of the foremost of all French women of science.

Mary Somerville, Caroline Herschel, and Sophie Germain were not, however, the first women in modern times to devote themselves to scientific studies. Even in the seventeenth century, and amidst the disasters and miseries of the Thirty Years' War, we hear of the German astronomer, MARIA CUNITZ, with the assistance of her husband, compiling new astronomical tables, which, after much delay, were published at Frankfort in 1654. Maria Cunitz died in 1664. To the seventeenth century also belongs the work of JEANNE DUMÉE, the French authoress of an unpublished memoir on the views of Copernicus, and of ELIZABETH KOOPMANN, the wife of Hevelius, the celebrated astronomer of Dantzig. Hevelius died in 1687, but for ten years his wife had been his ablest assistant, and after his death she published the two works, "Prodomus astronomiæ" and "Uranographia, seu firmamentum Sobescianum." Another German astronomer of the seventeenth century, George Eimmart, found in his daughter, MARIE CLAIRE, a valuable co-worker, and for him she made some hundreds of drawings of sunspots, comets, and eclipses.

Among the women of science of the eighteenth century, one name, that of the Italian mathematician, MARIA GAETANA AGNESI (1718–99), stands out clearly. When only eleven years of age she knew eight languages and in her twentieth year she published a collection of ninety-one theses she had previously defended. Her "Instituzioni Analitiche," published in 1748, long continued a valued textbook on the calculus, and is regarded as the first important mathematical work by a woman. This work had been preceded in 1740 by the "Institutions de physique" of the remarkable Frenchwoman, GABRIELLE-ÉMILE CHASTELET (1706–49), the friend of Voltaire, and to her we also owe a translation into French of the "Principia" of Newton. This was not published until after her death. While the names of these two distinguished women belong to the history of mathematics, those of MARGARETE WINCKELMANN (1670–1720), the wife of Gottfried Kirch, and of NICOLE-REINE ÉTABLE DE LA BRIÈRE (1723–88), the wife of Jean André Lepaute, belong to astronomy. Madame Kirch, the wife of one astronomer and the mother of another, while at Berlin discovered a comet and made observations on the Aurora Borealis, and, after she became a widow, she published in 1712 a paper on the ap-

proaching conjunction of Jupiter and Saturn. Madame Lepaute from an early age had displayed a taste for science, and when at the age of twenty-five years she married the celebrated horologist she at once became his collaborator. She was also the friend of Clairaut and Lalande, and assisted them in the calculations on Halley's comet. Her own observations are contained in the "Connaissance des temps," 1759–74. The last years of her life were devoted to her husband, who was struck down with sickness, and she died at Saint Cloud a few months before him. Another woman of science of the eighteenth century was DOROTHEA ERXLEBEN (1715–62), who in 1742 published a work on the cultivation of science by women, and in 1754 was made a doctor by the University of Halle.

Though today women are found working at every branch of science, it has been mainly in the realm of astronomy they have hitherto done their most notable work. Following in the footsteps of Mary Somerville and Caroline Herschel, during the nineteenth century a succession of women made their mark either as observers or as writers on astronomy. MARIA MITCHELL (1818–89) was long the professor of astronomy and director of the observatory at Vassar College in the United States. She was provided by the women of America with a large equatorial, and the observatory at Nantucket, now under the direction of MISS MARGARET HARWOOD, was erected in her honor. Two other American women, ANNA WINLOCK, who died in 1904, and MRS. WILLIAMINA FLEMING (1857–1911), were connected with Harvard University. Especially important were the writings of MISS AGNES MARY CLERKE, who was born in County Cork in 1842 and died in London in 1907. Her sound judgment and her wide acquaintance with astronomical literature made her "History of Astronomy during the 19th Century" a most valuable book of reference. This work first appeared in 1885, and was followed by her "System of the Stars," 1890, and "Problems in Astrophysics," 1903. Her most eminent woman contemporary in England was MARGARET MURRAY, who in 1875 married Sir William Huggins. Like Caroline Herschel, Mary Somerville, Anne Sheepshanks, Miss Clerke, and Mrs. Fleming, Lady Huggins enjoyed the distinction of being elected an honorary member of the Royal Astronomical Society.

In other branches of science, mention may be made of the Russian mathematician, SOPHIE KOVALEVSKY (1850–91), who studied under Weierstrass at Berlin, and in 1884 was made professor of higher mathematics in the University of Stockholm; MRS. AYRTON, the first woman member of the Institution of Electrical Engineers, and who was proposed for admission into the Royal Society; MARIE SKLODOWSKA, better known as Madame Curie, famous for all time as the discoverer of radium; and DOROTHEA KLUMPKE, who in 1893 was the first woman to obtain the doctor's degree in the mathematical sciences at the Sorbonne. Her thesis was a study of the rings of Saturn. It was when granting her the degree that M. Darboux said that her work gave her a place beside Maria Agnesi, Sophie Kovalevsky, and Sophie Germain. To this short sketch of some women of science other names might be added, but from what has been said it will be seen that France, England, Switzerland, Russia, Italy, Germany, and America are all represented, showing that the women of science, like science itself, have been confined to no one country or age.

Abstracts

TEACHING OBJECTIVES, METHODS, AND SUGGESTIONS

The Learning Value of Some Motion Pictures in High-School Physics and General Science as an Illustration of a Simplified Technic in Educational Experimentation. See this title, page 1880.

ADMINISTRATIVE PROBLEMS AND DEVICES; CURRICULA

The Harvard House Plan. A. L. LOWELL. *Assoc. Am. Colls. Bull.*, **17,** 89–96 (Mar., 1931).—The object of the Harvard House Plan is to produce a new atmosphere and attitude toward all college work by a closer contact of students with teachers. Each house is organized with a master at its head and a body of tutors—the unmarried ones having suites wherein they live, the married ones who live away, rooms where they meet their pupils. Then there is a small body of associates—older men of the faculty who have the privilege of table and the common room. Membership of the student is at present voluntary; but the students are required to take one-half their meals in the house. Two houses have been established, one of which has a master of more democratic leanings than the other. Which will have the better effect remains to be seen. The House Plan is an experiment but an experiment not in housing but in serious self-education. G. O.

A Proposed Plan of Honors or Tutorial Work for Colgate. See this title, page 1883.

Function of the Independent College. M. E. PARK. *Assoc. Am. Colls. Bull.*, **17,** 46 (Mar., 1931).—Side by side with other institutions the independent college has in its hands the training of young people between 18 and 22 who are to take their place in life. This type of college has this advantage; all attention can be placed upon the individual. Again the college is not affected by questions of professional and vocational education or wide research facilities or community responsibilities. Then, too, it is not overwhelmed by numbers, and finally it can pretty well control conditions of living and make them dovetail with life in the classroom and laboratory. G. O.

The Function of the College in the Independent University. G. A. WORKS. *Assoc. Am. Colls. Bull.*, **17,** 130–8 (Mar., 1931).—This is a discussion of the changed program of the University of Chicago. The University as it is now organized is composed of the college and the four divisions: Humanities, Biological Science, Physical Sciences, and Social Science, and the several professional schools, each presided over by a dean. No definite period of years has been set for the college. The completion of work in this unit will be determined by the ability of the student to meet a comprehensive examination. It is assumed that the average student will spend two years in the college, but some students will meet the tests in less than two years. The curriculum is devised to meet two purposes—to prepare the student for future study and to give the student a good general education. The suggested procedures are: a lecture course in the four fields represented by the four divisions with optional attendance; conference groups for each division. The present organization has for its primary object the facilitating of research and of instruction. President Hutchins in reply to criticisms has frequently emphasized the fact that the plan is not perfect, but it seems at least certain to bring a material modification of the function of the college in the University of Chicago. G. O.

Intellectual Life in the Colleges. L. P. EISENHART. *Assoc. Am. Colls. Bull.*, **17,** 5–8 (Mar., 1931).—This number of the *Bulletin* is devoted to the addresses and proceedings of the 17th annual meeting of the association, and this article is the annual address of the president in which he outlines principally what the executive committee proposes to do for the development of the intellectual life in the colleges. In a previous *Bulletin* there were some six or seven methods which different colleges are using, all worthy of investigation; but what the executive committee wishes to do is have an objective report on one of them; namely, the results of the comprehensive examinations in colleges and liberal arts colleges and the report presented in such a form that the advantages of the various systems may be given in such a manner that the colleges may decide whether to adopt certain or all of their features. G. O.

The Liberal Arts College in the State University. W. L. BRYAN. *Assoc. Am. Colls. Bull.*, **17,** 126–9 (Mar., 1931).—The most serious enemy of the liberal arts college ideal is not any professional or technical school but the liberal arts college as it exists today.

Our departmental system which has displaced the general, non-vocational curriculum of fifty years ago tempts every department in the college to become primarily a breeding place for specialists. G. O.

Current Changes and Experiments in Liberal Arts Colleges. C. S. BOUCHER. *Assoc. Am. Colls. Bull.*, **17**, 178–95 (May, 1931).—Some of the more significant changes which have been widely instituted are: selective admission, educational guidance and personnel work, course offerings, new methods of instruction, educational measurements, and alumni education programs. During the last few years more and more colleges have set minimum standards for entrance until now we have the greatest variety of requirements. We no longer ask the question, "Where are you going to college?" but "What college are you able to enter?" During the early history of our colleges there was no need for guidance because the curriculum was fixed. Then came the wide-open selective system. Today the better colleges are trying to strike a happy medium by specifying degree requirements in meaningful terms and by providing an educational guidance service. Recently new course offerings have appeared in a well-ordered, progressive sequence. Many institutions are realizing today that graduation from college does not mean the end of the educative process and have prepared syllabi for their alumni to pursue as reading or in serious study; alumni week has been transformed into an educational week with lectures to suit many tastes and interests. G. O.

KEEPING UP WITH CHEMISTRY

First Report of the Committee on Atomic Weights of the International Union of Chemistry. G. P. BAXTER (*Chairman*), MME. M. CURIE, O. HÖNIGSCHMID, P. LE BEAU, AND R. J. MEYER, *J. Am. Chem. Soc.*, **53**, 1627–39 (May, 1931).—This report covers reviews of investigations on atomic weights published since January 1, 1930. The Table of International Atomic Weights for 1931 as published by the *Journal of the American Chemical Society* in the June, 1931, issue may be found on the insert between p. 1876 and 1877 of this issue of the JOURNAL OF CHEMICAL EDUCATION. M. W. G.

Concentrating the Ore. ANON. *Inco*, **10**, 20–2 (1931).—The following three abstracts deal with processes used in copper-nickel production in Ontario, Canada. The ore as it comes from the mines is first crushed. The finest is removed, and the coarser is ground until it will pass a 100-mesh screen. The valuable sulfide ore particles are made to "ridge bubbles" in the flotation machines, and thus may be separated from the rock. A recent development in the flotation process is known as differential flotation, since some ore particles are more easily floated than others. By this means a partial separation may be made of the copper and nickel sulfides. These concentrates are treated separately in the smelter. The water is removed from the concentrates by allowing the coarser particles to settle out, while it is removed from the finer particles by partial vacuum filtration through canvas. H. T. B.

The New Smelter. ANON. *Inco*, **10**, 23–6 (1931).—Smelting consists, in general, of three steps; separation of rock, removal of iron, and elimination of sulfur. The first step is the partial removal of sulfur in roasters. The roasted ore goes by gravity to reverberatory furnaces where the slag is separated. Then the matte, or metal-bearing portion, is put into converters in which the iron is slagged off with siliceous flux, and the sulfur blown out if the ore is one containing little nickel. All the sulfur cannot be removed from a copper-nickel mixture or the matte would solidify at the temperature of the converter. The converter product, which is now called "white metal" or blister copper as the case may be, is cast into molds and is ready for the first stage of refining. H. T. B.

The Refining Operations. ANON. *Inco*, **10**, 27–8 (1931).—The white metal is smelted with niter cake and coke. Copper sulfide is soluble in the sodium sulfide while the nickel sulfide is not, and the mixture separates into layers which may be broken apart when cold. The copper-bearing tops are treated in converters to oxidize the sodium sulfide to sodium sulfate which is removed. The copper sulfide is then blown free from sulfur and cast as blister copper ready for electrolysis. The nickel-bearing bottoms are coarsely ground, leached with water, sintered, crushed, and charged into anode furnaces from which it emerges as crude anodes which are electrolyzed to produce pure nickel. A by-product of these processes is the group of noble metals, silver, gold, and the platinum group. These are concentrated and sent to the platinum refinery. H. T. B.

Copper-Nickel Production in Canada. See the three abstracts immediately above.

The Tinplate Industry. D. GRIFFITHS. *Chem. & Ind.*, **50**, 431–7 (May 22, 1931).—Tinplate is a combined product of iron (or steel) and tin. Generally it consists of nine parts iron to one part of tin, the surface of contact where the two metals cohere being a

good alloy. Tinplate has been made since early times and has long been the basis of an important industry in the British Empire. Processes of metallurgy of iron and tin, and methods of making tinplate are given in some detail. E. R. W.

Cellulose Acetate Plasticizers. *Syn. Org. Chem.*, **4** (May, 1931).—A brief discussion of the compounds used to give certain characteristics to cellulose acetate. H. H. K.

The Chemical Constitution of Coal. W. A. BONE. *Chem. & Ind.*, **50,** 407–16 (May 15, 1931).—The study of this subject should be treated as a problem of organic chemistry. Experimental methods for such a study are described. These have to do especially with the products of thermal decomposition and with the materials extracted by different solvents. The results of such studies as have been carried out are discussed. E. R. W.

Dust, Exploding Like Dynamite, Costs Millions. E. W. TEALE. *Pop. Sci. Mo.*, **118,** 28 (June, 1931).—Any material that burns is an extremely dangerous explosion and fire hazard, when finely divided and distributed in the air. Dust explosions in recent years have wrecked many factories, resulting in the loss of lives and millions of dollars. The Department of Agriculture has created a special branch to study the dust hazard. Coal, grains, starch, sugar, aluminum, zinc, sulfur, and sawdust are among the materials that are industrial hazards when in the form of dust. Factories are being equipped to reduce the dust content of the air, and also to eliminate the cause of the ignition. Any flame, hot bearing, static electricity, heat from hot electric bulbs, or sparks from electrical switches may be sufficient to set off the dust. H. T. B.

Bleaching. ANON. *Silicate P's & Q's*, **11** (June, 1931).—Bleaching of fabrics falls into two types of operations; cleansing, to remove foreign matter, and chemical alteration of colored materials. Cleaning helps, but the resulting fabric is still too colored to be used for delicately tinted fabrics. Peroxide bleaching is widely used, and is best done in an alkaline bath. Silicates of soda may be used to provide the proper alkalinity, and have the advantage of furnishing a buffered solution so that maximum efficiency may be more nearly attained throughout the operation. Preliminary work on chlorine solutions containing silicate of soda show promising results. H. T. B.

Yttrium. See **The First of the Rare Elements. "A Classic of Science."** Page 1879.

The First of the Rare Elements. "A Classic of Science." See this title, page 1879.

Other than War. J. C. BROWNE. *Chem. Warfare*, **17,** 959–65 (May, 1931).—A popular article describing the non-military activities of the Chemical Warfare Service. Among such activities are: protection of marine piling, combating the boll weevil, ship bottom paints, methods of fumigation, development of public health service masks, ammonia masks, use of tear gas in controlling mobs, protection against carbon monoxide poisoning. E. R. W.

The Stars and the Nightshades. EDIT. *Am. J. Pharm.*, **103,** 179–82 (Apr., 1931).—The primitive medicine man was a star-gazer. Hippocrates advised his son to study "geometry and numbers (astronomy) because the rising and setting of the stars have a great effect on distempers." Flammarion, the brilliant 20th century astronomer, pointed out the reciprocal influence of the stars "upon the earth, its elements, and organized existence thereon." Berthelot in a session of the Acadèmie des Science (1926) declared that the stars and meteors exercise a direct influence upon the body and the nervous system of man. Medical botany is filled with astrology. We are in accord, however, with the ancients as to the action of the sun and light rays upon living things. Today we are curing disease by the aid of natural, artificial, and "canned" rays of light. Extensive research is being made at the present time as to the action of light upon certain chemical substances and medicinal preparations. We are slowly coming to the realization of the properties of light in conjunction with such substances as fluorescent dyes. Modern literature upon the solanums attribute the variation in kind and quantity of their alkaloids to the weather conditions under which the plants have grown. We are far away from the fantastic dreams of the astrologers, but who knows but that the rays of the sun, moon, and stars may yet activate the power of the narcotic nightshades and other drugs. G. O.

The Revolt of the Biochemists. P. A. LEVENE. *Chem. Bull.*, **18,** 164–6 (June, 1931).—The revolt of the biochemist against the concept of "vital force" began in 1828 when Wöhler synthesized urea, but it attained momentum only when Berthelot wrote in 1860—"The objective of our science is to banish 'life' from the theories of organic chemistry." Berthelot had evidence to back his statement. Since then the biochemist has been learning to duplicate processes formerly thought possible only in the living organism.

Discoveries of science yield new conceptions, new tools, and invariably new problems.

"Step by step, one mystery of life after another is being revealed. Whether the human mind will ever attain complete mastery of life is not essential. It is certain, however, that the revolt of the biochemist against the idea of a restriction to human curiosity will continue." H. T. B.

Experimenting with Millions of Volts. W. DAVIS. *Sci. News Letter*, **19**, 326–7 (May 23, 1931). [*Cf.* J. CHEM. EDUC., **8**, 1658–9 (Aug., 1931).]—"In four great laboratories in Berlin, Pasadena, Schenectady, and Washington a friendly race is in progress to build larger vacuum tubes that operate at larger voltages and produce more intense radiations."

At Washington tubes have been built that operate at about 2,000,000 volts. From these tubes have come the most penetrating radiation ever generated by man. This radiation is not only more penetrating but more powerful, more capable of harm or good than radiations from radium itself.

Man has little control over radium radiation even though it does send forth three kinds. These new tubes can duplicate all three of radium's rays and, what is more important, they can deliver those radiations just when and where desired.

The tremendous electrical pressures used in these tubes have given beta rays such speeds that they actually go only one per cent slower than light.

With such "electrical shoves" attainable experimenters hope to attack the very heart of matter, the atomic nucleus. Such experiments may reveal something of the character of that region of the world of matter so little understood at present.

Something of the advantages, other than those already mentioned above, which these tubes have over radium for experimental purposes can be better appreciated when it is learned that the tube at Pasadena is capable of producing rays equal in intensity to those from twenty pounds, $500,000,000 worth, of radium. B. C. H.

HISTORICAL AND BIOGRAPHICAL

F. W. Aston. (*1*) *Les Prix Nobel en 1921–1922.* P. A. Norstedt & Söner, Stockholm, Sweden, **1923**, pp. 84–7, 130–1, 1–14 (back of book).—These references are to an account of the bestowing of the Nobel Award upon Aston, biographical sketch, portrait, and address delivered by Aston on "Mass-Spectra and Isotopes." (*2*) V. JUNK, "Die Nobelpreisträger, Dreissig Jahre Nobelstiftung," Verlag Michael Winkler, Wien, Leipzig, **1930**, p. 126.—Biographical sketch and portrait. (*3*) O. KLEIN. *Teknisk Tids.*, **52, Uppl. A.**, 827–32 (1923).—This article contains a brief summary of the work of Einstein, Bohr, Soddy, and Aston up to the time they received the Nobel prizes. The relations between the ideas of the four men are brought out. Portraits of each are included. (*4*) F. W. ASTON. *J. Franklin Inst.*, **193**, 581–608 (May, 1922).—A summary of a series of lectures given before The Franklin Institute, March 6–10, 1922, on the subject "Atomic Weights and Isotopes." M. W. G.

Berzelius. *Laboratory*, **4**, 19–20 (1931).—Short biographical sketch with portrait. H. H. K.

Benjamin Rush, Teacher of Chemistry. *Laboratory*, **4**, 35–6 (1931).—Rush occupied the first chair of chemistry in America. Biographical sketch. H. H. K.

Dr. Karl Landsteiner: Nobel Prize Laureate in Medicine, 1931. See this title, page 1883.

The First of the Rare Elements. "A Classic of Science." A. G. EDEBERG. *Sci. News Letter*, **19**, 314–15 (May 16, 1931).—This "classic of science" was first published in *Chemische Annalen* in 1799.

Professor Gadolin first announced an investigation of a black mineral from the Ytterby quarries in the year 1794. The author fell into possession of a "beautiful piece of the mineral . . . such that after breaking it up . . . little pieces" could be selected for analysis that were free from feldspar.

After describing his analysis, involving the earth's separation from alumina, iron, and other earths the author tells of some properties of compounds of this element which he considers important. Some are the sweet taste of its salts, especially the acetate, the solubility of its sulfate, and its insolubility in "caustic potash lye."

For a name, "it seems most fitting that it should be named for the place it was first discovered," Ytterby. Its earth could then be called Yttria and the mineral from which it was isolated, Ytter-stein. B. C. H.

Three Dimensional Molecules. "A Classic of Science." J. H. VAN'T HOFF. *Sci. News Letter*, **19**, 362–3 (June 6, 1931).—This "classic of science" is reprinted from van't Hoff's "La Chemie Dans L'Espace" published in 1875.

The author after paying tribute to organic chemistry as the mother of atomicity calls attention to the fact: "The number of isomers in existence surpasses that which

theory predicts." Put in another way, he says "present theory is unable to predict isomers exactly."

It was the author who suggested "a theory of structural formulas in space" as a means of bringing the facts and atomic theory into accord.

Such a theory must take a position upon two questions: first, what relative positions do the atoms occupy in the molecule, and second what of their motions within the molecule.

"There is always the objection that each motion changes the form of the system.... But the motion of the atoms in the molecule must be periodic; we can therefore show the relative position of the atoms in one phase of their motion."

Present formulas are not satisfactory because they try in two dimensions to represent a molecule which always has three dimensions.

After showing how the three-dimension conception helps to account for isomers not otherwise explained he summarizes by saying: "In the case where the four affinities of the carbon atom are satisfied by four groups different from one another, we can have only two different tetrahedra, which are mirror images one of the other, and can never doubt the idea, namely, that we are dealing with two formulas isomeric in space."

B. C. H.

Alchemical Symbols. *Laboratory*, **4**, 40–1 (1931).—A table giving sixty alchemical symbols. H. H. K.

The Fourth Centenary of the Collège de France. See this title, page 1883.

EDUCATIONAL MEASUREMENTS AND DATA

The Learning Value of Some Motion Pictures in High-School Physics and General Science as an Illustration of a Simplified Technic in Educational Experimentation. R. K. WATKINS. *Educ. Screen*, **10**, 135–7, 156–7 (May, 1931).—Most of the investigation concerning the relative merits of individual laboratory instruction and lecture demonstration in science teaching is weak in two respects; (1) failure to define or describe clearly the things compared, and (2) assumption that the complicated processes do work and the prime question is which works better. The author believes the question should be "do they work at all" rather than "which works better" because in comparing an automobile and a goose as means of transportation, it is first necessary to prove that the goose gets any measurable results.

Six films were shown to a class of sixteen in physics in the University High School of the University of Missouri. The films were Temperature Control, Magnetism, How We See, The Magic of Communication, Wizardry of Wireless, and Revelations of the X-Ray. The films were shown at different times during the course without any introduction other than an announcement of the general content. After the showing the pupils asked questions and the teacher answered them, but did not quiz the class. Then a final test was given. The tests used were home-made objective tests in the true-false and multiple-response forms based on the facts and ideas contained in the film so as to be valid for the teaching undertaken. In each case the same test was given before and after the film. The pupils gained from 28 to 106% on the tests used as a result of having seen the pictures. Four films of similar nature were shown to sixty pupils in general science in a Kansas City, Kansas, Jr. High School. Tests showed that the students gained from 33 to 146%.

"These pupils learned something from watching films on science topics and it seems probable that other pupils would learn from watching well-selected films on science topics." H. T. B.

College Graduates and Civilization. See this title, page 1881.

Why Freshmen Fail in College. H. A. FRENCH. *High Sch. Teacher*, **7**, 211–3 (June, 1931).—From her experience with freshmen entering the University of Pittsburgh who were seriously handicapped by inability to read, Mrs. French gives the following answer to the article's question. Freshmen fail at the University of Pittsburgh because: (1) they cannot read factual material, (2) they read too slowly to cover assignments, (3) they cannot retain material because they do not know how to organize it for such retention, (4) their vocabularies are inadequate for reading on a college level, (5) they have no reading background, (6) they have not mastered tool subjects, (7) they cannot study. B. C. H.

The Significance to the Churches of the Junior College Developments. B. W. BROWN. *Assoc. Am. Colls. Bull.*, **17**, 259–80 (May, 1931).—The title is misleading for the article is a good, general summary of the growth and development of the junior college; its cost per student and its scholarship; its objectives and its present organization and status. There are two paragraphs devoted to the relation of the church col-

leges to junior colleges and the relative value of the latter to the church. The states highest in number of junior colleges are California, Texas, Iowa, and Missouri. These four states contain 145 junior colleges and only 216 junior high schools, while Massachusetts, Pennsylvania, Ohio, and New York have 466 public junior high schools and only 34 junior colleges, a ratio of less than 1:13. G. O.

THE PHILOSOPHY OF EDUCATION

Mass Education at College Level. K. D. MACMILLAN. *Assoc. Am. Colls. Bull.*, **17**, 97–111 (Mar., 1931).—There are two philosophies of education in our midst; namely, the mass method and the individual method. We would do well not to argue which one of these is right and which is wrong, but rather recognize that both are right and both necessary if we are to carry through the program of education implied in American institutions. Mr. Macmillan spends some time examining some of the difficulties connected with the individual method. The first of these is the difficulty of finding the more gifted student early. The second problem is that of finding enough teachers who have the ability and the training and, above all, the rich personality necessary to inspire and guide students of superior mental caliber. Our American institutions are not doing enough to find such teachers and to keep them. When a sufficient number of schools have introduced the comprehensive examination and have learned how to give them and evaluate them, we may be able to arrange an exchange of faculty members for this purpose and thus solve the problem of suitable examiners. He suggests to those who are interested in the problem that they study the work of the University of Toronto which admits students at two levels, that of the "pass matriculation" and that of the "honors matriculation," since there are always in every institution two kinds of students, those who are only capable of carrying on and those better students whom we are anxious to train for better things. G. O.

The Newer Education. R. WITHINGTON. *Assoc. Am. Colls. Bull.*, **17**, 228–32 (May, 1931). This writer believes that the greatest problem before educators today is that of teaching students "how to think." The various "honors systems" are correcting this defect to a certain extent but only for a picked group. When the practice becomes general and (as already in some places) is applied to the undergraduates, as a whole, a great gain should result. G. O.

Intellectual Life in the Colleges. See this title, page 1876.

Function of the Independent College. See this title, page 1876.

Current Changes and Experiments in Liberal Arts Colleges. See this title, page 1877.

A Proposed Plan of Honors or Tutorial Work for Colgate. See this title, page 1883.

The Significance to the Churches of the Junior College Developments. See this title, page 1880.

College Graduates and Civilization. M. LEE. *Harpers*, **162**, 719 (May, 1931).—This article is an answer to the charge often made against the graduates of women's colleges that they have a strange aversion to matrimony and are allowing the race of intelligent people to die off.

The answer is that college graduates are more interested in propagating spiritual quality than physical numbers. They are doing the teaching, leading, and learning. It is pointed out that education cannot be passed on to children. No matter what their ancestry all children must pass through the same learning processes. Graduates are teaching the right sort of traditions, ideals, and standards and in the best possible way.

Sixty per cent of the total woman population of the country are married. This is only $10^1/_2$ per cent more than that for college women. There are no accurate figures as to comparative numbers of children, but college women probably have less because they realize it is impossible to properly care for five on an income meant for three.

Prominent women graduates in the fields of education, public affairs, writing, etc., are listed as proof of their interest in the spiritual survival of the race. J. W. H.

College Men in Business. R. I. REES. *Assoc. Am. Colls. Bull.*, **17**, 112–8 (Mar., 1931).—Mr. Rees, vice-president of the American Telephone and Telegraph Co., takes a close view of the manner in which the liberal arts graduate fits into business and industry. The pressing problem in business today, as he sees it, is concerned with human relationships more than with material things. In terms of education this means that education must equip the potential industrial leader with a fund of knowledge, of biology, psychology, sociology, economics, and the humanities—in short, the curriculum of the liberal arts college, for the college man will need them all in business. It is important that the students in such colleges have a clear-cut career objective. It

would be an enormous relief to representatives of industry whose reponsibilities involve the employment of college men to find upon interviewing them that they do have this clear-cut objective. Vocational counseling and personnel departments in colleges are giving great encouragement to industry. G. O.

College-Made Citizens. A. R. ELLINGWOOD. *Assoc. Am. Colls. Bull.*, **17**, 200–7 (May, 1931).—Citizenship is the one objective upon which American educators agree. The writer feels that the liberal arts college has a special responsibility in the task of making better citizens. A course in current problems offered in the senior year is suggested because it seems the best possible time to emphasize this objective because of the student's proximity to responsible citizenship. Current problems seem desirable, for they are concrete and practical. G. O.

PROFESSIONAL

The Importance of the Teacher and of Teaching. P. E. TITSWITH. *Assoc. Am. Colls. Bull.*, **17**, 233–7 (May, 1931).—Too frequently has the teacher been looked upon as an "unimaginative, futile being, given over to theories and a pointless, scholastic rigamarole." This stigma teachers find difficulty in throwing off. The notion persists even today that the teacher occupies an inferior social position and enjoys a "soft-snap job." Surveys undertaken among recent alumni of well-known colleges seem to bear out the fact that the work and personality of teachers were a rather negligible factor in their education. However, outstanding teachers did call forth favorable comment. During the last five years administrators have fully awakened to the necessity of better teachers. In this new age colleges must be willing to put money into persons as well as equipment. "True teaching is hard work. It demands all that he knows, is, and can become. In class the teacher must challenge the brightest students, stir the sluggards, keep the group thinking. Outside of class, he must 'make contact' with his students, he must read and grade written work, make reports (a sizeable job in itself), and at the same time keep his own contacts fresh and stimulating. His task is never done." G. O.

Report of the Commission on Enlistment and Training of College Teachers. E. H. WILKINS. *Assoc. Am. Colls. Bull.*, **17**, 24–36 (Mar., 1931).—Two years ago this commission presented a report dealing with the second of these two problems. The commission thinks that the enlistment of prospective college teachers is far too important a matter to leave to chance or undirected student initiative. Therefore, it proposes first a simple factual inquiry to ascertain things with regard to the graduates of each college which is a member of the association; first, the actual number of members of each of the last ten graduation classes who are engaged in teaching or preparing for college teaching; and second, the actual number of persons in the upper quarter of each of the ten graduating classes who are engaged in or preparing for college teaching. The enlistment of college teachers means, in the main, the enlistment of college students before they graduate from college. If college teaching is to appeal to the undergraduate, it must be made attractive. The commission would appeal to the student by making teaching interesting in itself; the human relationships involved stimulating; the work must afford a chance for freedom of thought and speech and it must afford a chance for distinction; a chance for service; and give promise of financial competence as a basis for a happy life. The commission also adds six suggestions bearing on the enlistment of teachers while they are undergraduates. They are: first, the profession of college teaching be adequately presented in a proper course; and second, on an appropriate occasion, on Honors Day, for example, some faculty member, to whom the students listen gladly, set forth the values of the scholastic life; third, at the period when majors are being chosen the advisers suggest to able students the possibility of college teaching as a career; fourth, that professors teaching the majors suggest to their students the profession of college teaching; fifth, that the association prepare a booklet designed for the benefit of undergraduates interested in teaching; and sixth, discourage any student from entering the profession who gives no promise of becoming a good teacher. G. O.

Report of the Commission on Faculty and Student Scholarship. H. M. WRISTON. *Assoc. Am. Colls. Bull.*, **17**, 37–40 (Mar., 1931).—This commission is concerned with the maintenance of teachers upon a level of their highest personal and scholastic efficiency. We have objective evidence to prove that many teachers lose in teaching power during their continuance in our institutions. A shocking percentage never goes on with research after receiving degrees. Our graduate schools have given the units of scholarship to men and women who never were and never will be scholars. The fault with our teachers lies, however, in the fact that we often require too much teaching over too wide a

range of subjects. It is with this background in mind that the commission is concerning itself. The commission seeks data upon the readings of professors in a representative college group in order to give some objective evidence as to what extent college instructors read general contemporary literature and their professional literature; what differences appear in the reading habits of instructors in various departments. It also desires to know the size of the library to which the instructors are attached, the library appropriation, the policies governing library purchases, the teaching load of the professor, and his administrative work as well as college routine. G. O.

Appropriate Use of Professors. See page 1889.

Research Foundation of the University of Wisconsin. See page 1889.

CONTEMPORARY NEWS AND COMMENTS IN CHEMISTRY AND EDUCATION

A Proposed Plan of Honors or Tutorial Work for Colgate. C. H. THURBER. *Assoc. Am. Colls. Bull.*, **17,** 196–9 (May, 1931).—The plan itself is this—each student will be expected to attend two seminars a week from two and one-half to three hours at a time. Fifty per cent of the honors work during the last two years would be devoted to the field in which the student was concentrating and the other fifty per cent would be divided between two other fields vitally related to the field in which he is majoring. These honor students will be permitted to attend as many or as few of the regular classes as may seem profitable. The proposed plan has as its objective the education of the individual. It is hoped to set up a program which will be so flexible that a student may progress as rapidly as possible if his superior capacity and achievements warrant it. He will be allowed to graduate whenever he is able to demonstrate that he has developed the proper power. G. O.

The Harvard House Plan. See this title, page 1876.

Program of Studies at the University of Chicago. See **The Function of the College in the Independent University,** page 1876.

Association of American Colleges. See **Intellectual Life in the Colleges,** page 1876.

Report of the Commission on Enlistment and Training of College Teachers. See this title, page 1882.

Report of the Commission on Faculty and Student Scholarship. See this title, page 1882.

Dr. Karl Landsteiner: Nobel Prize Laureate in Medicine, 1931. S. BAYNE-JONES. *Science,* **73,** 599–604 (June 5, 1931).—This article contains a brief survey of the accomplishments of Landsteiner given in a presidential address delivered at the annual meeting of the American Association of Immunologists, April 1, 1931, at Cleveland, Ohio. G. H. W.

Founder's Day Exercises at the Philadelphia College of Pharmacy and Science. See **Heralds of Progress,** page 1884.

The Fourth Centenary of the Collège de France. *Nature,* **127,** 929–30 (June 20, 1931).—The Collège de France, one of the great educational institutions of Paris, founded by Francis I in 1530, celebrated its four hundredth anniversary the week of June 18 to 20. The present building in the Sorbonne was commenced in 1610 and was completed about 1778. Bearing over its doorway the inscription "Docet Omnia," the Collège today possesses more than forty chairs, and all its lectures are public and free. Its professors have contributed very greatly to the furtherance of science and learning in France.

To chemists the following list will indicate how much our own science owes to men who have been sheltered in its walls: Duhamel (1624–1706), Darcet (1725–1801), Vauquelin (1763–1829), Thénard (1777–1837), Biot (1774–1862), and Ampère (1775–1836) who were physicists, but their work had much influence on chemistry; Regnault (1810–78), Pelouze (1807–67), Balard (1802–76) who was the discoverer of bromine; Berthelot (1827–1907), one of the great figures of the last century; and Schützenberger (1829–97).

This is the record of one science alone. The contributions to mathematics, physics, and physiology are of the same order. F. B. D.

Final Program of Division of Chemical Education, Buffalo Meeting of the A. C. S., August 30–September 4, 1931. See page 1885.

The Buffalo Meeting of the American Chemical Society. See page 1887.

Appropriate Use of Professors. See page 1889.

Research Foundation of the University of Wisconsin. See page 1889.

The Growth of College and University Education in the United States. See page 1890.

Masters of Colleges at Yale University. See page 1891.

The Alumni University of the University of Michigan. See page 1892.
The Increase of High-School Students in New York City. See page 1893.
Children Are More Alert than Their Teachers. See page 1893.
"Science Research Requires Salesmen" Subject of Dr. Bancroft's Dedicatory Address at the University of Southern California. See page 1894.
Molecules as Much Smaller than Man as Stars Are Larger, According to Dr. Swann. See page 1895.
Cheaper Hydrogen for Industry Promised. See page 1895.
Substance of Digestive Juice Prepared Pure. See page 1896.
Vitamins A and B Print Initials on Photo Plates. See page 1897.
Gifts and Requests to Universities and Colleges. See page 1897.
Tuition Increase at Smith College. See page 1898.
Undergraduate Scholarships at Colgate University. See page 1898.
Staff Changes and Student Awards at Grinnell College. See page 1898.
New Science Ship on Way to America. See page 1898.

GENERAL

The Recent Change of Attitude toward the Law of Cause and Effect. P. W. BRIDGMAN. *Science*, **73**, 539–47 (May 22, 1931).—"It is now becoming common knowledge that one of the most startling developments of the altogether surprising progress of physics in the last few years has been a weakening of the belief of the physicist, at least, in the validity of the causality principle. I want to examine with you this situation—to enquire in what sense we are losing our conviction of the validity of the causality principle, and to discover some of the implications. I want especially to emphasize that I am concerned only with the objective aspects of the situation. The idea of causality which we shall discuss is as remote as possible from the subjective questions of free will or determinism which are often associated with it, both in popular discussions and in a number of recent more technical discussions by scientific men. We shall be concerned only with the domain accessible to experiment, and the causality principle, in the sense in which I use the term, is a principle dealing with the findings of actual experiment." This, an introductory paragraph from the address delivered at the University of Wisconsin, April 21, 1931, gives the purpose of the paper. G. H. W.

Heralds of Progress. J. C. KRANTZ. *Am. J. Pharm.*, **103**, 218–35 (Apr., 1931).—This is an address delivered at Founder's Day Exercises of the Philadelphia College of Pharmacy and Science, but it is an appeal for investigators and pure research in the fields of science. Chemistry, physics, and biology have all served humanity because of the courageous spirit of the research worker. The achievements of the men who have left us a "goodly heritage" is the challenge of the speaker. G. O.

A New Box of Wonders. W. S. DUTTON. *American*, **91**, 22–3 (May, 1931).—"A peer into the future," according to the author, reveals: "the evolution of modern radio reception into a home theater, vitamized food as a substitute for less sunlight, glass skyscrapers, and frost-proof, non-skid self-illuminated highway construction materials."

These prophets of the new industrial order span thirty to forty years in their plans for the future of their industries. That these seers are taken seriously by American industry is testified in the $200,000,000 spent annually upon research. Thus do they make ready for the unexpected even as far as fifty years hence. B. C. H.

Intelligence Tests Criticized by Psychologist. The clinical use of the so-called intelligence tests should be regarded as an art and not a science, since the results are not sufficiently exact to be truly scientific, according to Blanche M. Minogue, psychologist at Letchworth Village, Thiells, New York.

"Intelligence itself we do not understand and cannot measure," she says.

Miss Minogue recommends a combination of tests showing ability to understand verbal abstractions, performance and achievement tests, and tests for special abilities and disabilities when determining a child's mental grade and general ability. She recommends also that emphasis be placed on the study of the higher grade defectives, since most can be hoped for from training and guidance of these individuals.—*Science Service*

Contemporary News in Chemistry and Education

FINAL PROGRAM OF DIVISION OF CHEMICAL EDUCATION, BUFFALO MEETING OF THE A. C. S., AUGUST 30–SEPTEMBER 4, 1931

The complete program of the 82nd meeting of the A. C. S. is contained in the August 20 *News Edition* of *Industrial and Engineering Chemistry*, a copy of which will be mailed to any interested individual by SECRETARY CHARLES L. PARSONS, Mills Building, Washington, D. C.

Registration

Registration will be conducted in the Hotel Statler, August 30, 4:00–8:00 P.M., and August 31–September 2, inclusive, 8:00 A.M.–6:00 P.M. The convention registration fee, required to help carry local expenses, will be $3.00 for members and guests other than American non-member chemists, and $8.00 for American non-member chemists.*

Reservations

The Hotel Statler has been designated as general headquarters. Reservations in this or any other hotel should be made directly with the management. Specific information regarding accommodations may be obtained from DR. H. W. POST, Foster Hall, University of Buffalo, or from the *Local Secretary* of the Division.

Program

MONDAY, AUGUST 31

7:30 A.M. *Breakfast Meeting Executive Committee, Division of Chemical Education.* Hotel Statler.

9:30 A.M. *A. C. S. Council Meeting.* Hotel Statler.

12:00 M. *Executive Committee, Division of Chemical Education.* Hotel Statler.

2:00 P.M. *General Meeting.* Auditorium, Hutchinson High School, Symposium on "New Research Tools."

7:00 P.M. *Subscription Dinner* ($2.50), *followed by reception and dance.* Ball Room, Hotel Statler.

TUESDAY, SEPTEMBER 1

9:00 A.M. *Joint Symposium of the Division of History of Chemistry with the Division of Chemical Education.* "The History of Chemical Education in America." J. N. SWAN, presiding. Perkins Hall, Y.M.C.A.

9:00 A.M. J. N. SWAN, *Chairman*, "The Division of Chemical Education."

9:05 A.M. TENNEY L. DAVIS, *Secretary*, "The Division of History of Chemistry."

9:10 A.M. L. C. NEWELL, *Professor of Chemistry, Boston University*, "Period Up to 1820."

9:50 A.M. C. A. BROWNE, *Chief, Chemical and Technological Research, U. S. Bureau of Chemistry and Soils*, "Period from 1820 to 1870."

10:30 A.M. *Intermission.*

10:40 A.M. HARRISON HALE, *Professor of Chemistry, University of Arkansas*, "Period from 1870 to 1914."

11:20 A.M. F. B. DAINS, *Professor of Chemistry, University of Kansas*, "Period after 1914."

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* Associate members of the Division of Chemical Education *are not* members of the A. C. S.

12:15 P.M. *Luncheon, Division of Chemical Education.* Room 205, Y.M.C.A. Brief addresses by officers of the A. C. S., officers of the Division, editors of the JOURNAL OF CHEMICAL EDUCATION and *The Chemistry Leaflet,* and educational leaders in Buffalo.

2:00 P.M. *Miscellaneous Papers, Division of Chemical Education.* Perkins Hall, Y.M.C.A.

2:00 P.M. OWEN L. SHINN, *Professor of Chemistry, University of Pennsylvania,* "Edgar Fahs Smith as a Teacher of Chemistry."

2:10 P.M. M. V. MCGILL, *Director of Guidance and Instructor in Chemistry, Lorain High School, Lorain, Ohio,* "History of Vocational Guidance in Chemistry."

2:20 P.M. A. L. POULEUR, *Professor of Chemistry, Wheaton College,* "Atomic and Molecular Structure Models as a Visual Aid in the Teaching of Chemistry."

2:40 P.M. R. E. KIRK, *Professor of Chemistry, Montana State College,* "Research for the Undergraduate."

2:50 P.M. GILBERT B. L. SMITH, *Professor of Chemistry, Brooklyn Polytechnic Institute,* "Research in the Undergraduate Curriculum of Its Course in Chemistry."

3:00 P.M. L. E. STEINER, *Professor of Chemistry, Oberlin College,* "Contributions of High-School Chemistry to a College Chemistry Course."

3:10 P.M. JOSEPH ROSSMAN, *Chemical Engineer, U. S. Patent Office,* "What the Chemist Should Know about Patent Law."

3:30 P.M. *Intermission.*

3:40 P.M. R. D. BILLINGER, *Professor of Chemistry, Lehigh University,* "A Measure of Catalysis."

3:50 P.M. ROY I. GRADY, *Professor of Chemistry, College of Wooster,* "Chemistry in the College Curriculum of the Pre-Medical Student."

4:05 P.M. HOYT C. GRAHAM, *Professor of Chemistry, New Mexico State Teachers' College,* "A Study of the Academic Training of a Group of Chemistry Doctors with Respect to Their Needs as Teachers and Industrial Chemists."

4:15 P.M. W. F. COOVER, *Professor of Chemistry, Iowa State College,* "Chemistry in the Junior Colleges."

4:20 P.M. ALEXANDER SILVERMAN, *Professor of Chemistry, University of Pittsburgh,* "Glass Collecting as a Hobby."

5:00 P.M. *Editors' Meeting, Division of Chemical Education.* Hotel Statler.

6:00 P.M. *Editors' Dinner.* Hotel Statler.

8:30 P.M. *Smoker and Entertainment, followed by dancing* (complimentary to registered individuals). Ellinwood Music Hall.

WEDNESDAY, SEPTEMBER 2

7:45 A.M. *Breakfast Meeting, Group of Divisional Officers of A. C. S.* Hotel Statler.

9:00 A.M. *Meeting of the Senate of Chemical Education.* Perkins Hall, Y.M.C.A. (Division committees are invited to attend.)

11:00 A.M. *Meetings of All Committees of the Division of Chemical Education.* Perkins Hall, Y.M.C.A.

1:00–2:00 P.M. *Visual Aids Demonstration.* Perkins Hall, Y.M.C.A.

2:00 P.M. *Symposium on* "Visual Aids." M. V. MCGILL, presiding. Perkins Hall, Y.M.C.A.

2:00 P.M. F. DEAN MCCLUSKY, *Director of Scarborough School and President of the National Academy of Visual Instruction,* "A General Overview of Visual Aids in Teaching."

2:30 P.M. B. S. HOPKINS AND H. G. DAWSON, *Professor of Chemistry, University of Illinois,* "Visual Aids in Chemistry Teaching from the College Standpoint."

3:00 P.M. L. PAUL MILLER, *Scranton High School*, "Visual Aids in Chemistry Teaching from the High-School Standpoint."
3:30 P.M. *Intermission.*
3:40 P.M. I. E. MUSKATT, *Department of Chemistry, University of Chicago*, "Museum and Open-House Exhibits."
4:10 P.M. W. E. TROUT, JR., AND NEIL E. GORDON, "The Possibilities for the Use of Sound Film in Chemistry." (2 Reels of Sound Pictures.)
4:30–7:00 P.M. *Visual Aid Demonstration* (continued). Perkins Hall, Y.M.C.A.
6:00 P.M. *Group Dinners.*
8:30 P.M. *Address by the President of the A. C. S. and Medal Awards.* Hutchinson High School Auditorium.

THURSDAY, SEPTEMBER 3

7:45 A.M. *Breakfast Meeting, Group of A. C. S. Local Section Officers.* Hotel Statler.
9:00 A.M. *Miscellaneous Papers, Division of Chemical Education.* Perkins Hall, Y.M.C.A.
9:00 A.M. R. E. KIRK, *Professor of Chemistry, Montana State College*, "The Chemistry Teacher and Service Courses in the Land-Grant College."
9:10 A.M. V. F. PAYNE, *Professor of Chemistry, Transylvania College*, "The Distribution of Time between Chemistry Classroom and Laboratory."
9:25 A.M. RUFUS D. REED, *State Teachers' College, Montclair, New Jersey*, "Range of Subjects Taught, Teaching Load, and Preparation in Science of the Science Teachers of New Jersey."
9:40 A.M. GLEN WAKEHAM, *Professor of Chemistry, University of Colorado*, "Verbalism in Elementary Chemistry Teaching."
9:55 A.M. E. A. WILDMAN, *Professor of Chemistry, Earlham College*, "Modern Conceptions and the Teaching of General Chemistry."
10:15 A.M. JAMES KENDALL, *Professor of Chemistry, University of Edinburgh*, "Alexander Smith as an Educator."
10:30 A.M. *Intermission.*
10:40 A.M. EARL W. FLOSDORF, *Professor of Chemistry, Haverford College*, "Systematic Qualitative Analysis of Anions."
10:55 A.M. ARTHUR J. CLARK, *Professor of Chemistry, Michigan State College*, "Carbon Compounds in General Chemistry."
11:00 A.M. *Business Meeting, Division of Chemical Education.* Perkins Hall, Y.M.C.A.
1:30–10:30 P.M. *Trip to Niagara Falls.*

Student Attendance

As usual, the Division is attempting to stimulate student attendance by providing terminal facilities at little or no cost. Any graduate or undergraduate student who is interested should correspond at once with MR. JOHN MICHELSON, JR., *Local Secretary*, Division of Chemical Education, Trett Vocational School, Niagara Falls, N. Y.

R. A. BAKER, *Secretary*
17 Lexington Avenue
New York, N. Y.

THE BUFFALO MEETING OF THE AMERICAN CHEMICAL SOCIETY

The eighty-second meeting of the American Chemical Society will be held in Buffalo, New York, from August 30 to September 4. The registration office at the Hotel Statler will be open on Sunday, August 30, from 4 to 8 P.M., and

from 8 A.M. on the following days. At 2 P.M. on Monday there will be a general meeting at Hutchinson High School Auditorium and a symposium under the auspices of the Division of Industrial and Engineering Chemistry on "New Research Tools," under the chairmanship of DR. KARL T. COMPTON. Those taking part are expected to include F. G. COTTRELL, E. M. CHAMOT, R. B. SOSMAN, F. G. KEYES, W. A. PETERS, P. K. FRÖLICH, S. DUSHMAN, W. H. RODEBUSH, C. P. SMYTH, D. H. ANDREWS, G. L. CLARK, and J. B. NICHOLS. In the evening at 7 P.M. there will be a subscription dinner, and a reception by the officers of the society, followed by dancing and cards.

Tuesday and Wednesday will be devoted chiefly to divisional meetings and to group dinners and luncheons. On Wednesday evening at 8.30 P.M. PROFESSOR MOSES GOMBERG, of the University of Michigan, will deliver the address of the president on "Valence Variation and Atomic Structure," followed by the initial presentation of the LANGMUIR AWARD and of the J. F. SCHOELLKOPF MEDAL. Divisional meetings will be continued on Thursday and inspection trips will be made to the Buffalo Foundry and Machine Company, makers of chemical equipment, and the Dunlop Tire and Rubber Company. There will also be a sightseeing trip to Niagara Falls with transportation by high-speed trolleys. This trip will include an optional visit to the Niagara Falls Power Company's model of Niagara Falls, a trip through the power house on the American side of the Falls, and a trip around the Gorge Route. Visitors will assemble about 5.30 for a festival at Victoria Park on the Canadian side, where a picnic supper will be served. The festival will include music, exhibition sports, contests, and a special illumination of the falls.

On Friday optional inspection trips are planned to the Tonawanda Paper Company, showing some of the largest paper machines in the world; the Consolidated Aircraft Corporation, where the latest commercial models of planes will be exhibited and demonstrated; the Flexlume Corporation, manufacturers of neon signs and illuminated signs; the Curtiss Aeroplane Company, working exclusively on government orders for planes, and Huntley Station of the Buffalo General Electric Company, an unusual steam power plant.

All the divisions will hold sessions at Buffalo and a number of joint meetings and symposia have been planned. The Division of Biological Chemistry will hold a joint session on Tuesday afternoon with the Division of Agricultural and Food Chemistry and on Wednesday morning with the Division of Medicinal Chemistry on "The Biochemistry of the Fats," with W. R. BLOOR, G. S. JAMIESON, W. E. ANDERSON, R. J. ANDERSON, W. M. SPERRY, and L. H. NEWBURGH as speakers. On Thursday morning it will take part in a joint symposium on endocrines with the Division of Medicinal Chemistry.

For the program of the Division of Chemical Education see pp. 1885–7.

In addition to the symposium on "New Research Tools" the Division of Industrial and Engineering Chemistry will hold a joint meeting with the Divisions of Petroleum Chemistry and Gas and Fuel Chemistry. The Division of Petroleum Chemistry will also hold a joint symposium with the Division of Gas and Fuel Chemistry and the Division of Industrial and Engineering Chemistry on the "Utilization of Gaseous Hydrocarbons." PROFESSOR DONALD B. KEYES will act as chairman of this symposium.

A symposium on "Kinetics of Reactions" has been arranged by the Division of Physical and Inorganic Chemistry for Tuesday morning, which will probably extend through Tuesday afternoon.

The Division of Dye Chemistry expects to hold a three-session meeting divided into three topics: one devoted to spectro-

photometry, including papers on the various color analyzers and possibly an exhibit of the latest instruments; another on certain theoretical aspects, and the third given over to the usual miscellaneous papers.

The divisional officers will meet for breakfast on September 2 with ERLE M. BILLINGS presiding and FRANK C. WHITMORE acting as secretary, and the local section officers on September 3 with H. T. HERRICK presiding and ELLICE MCDONALD as secretary.—*Science*

APPROPRIATE USE OF PROFESSORS

Last year four men refused appointments in the psychological section of the Philosophy Department of Harvard almost entirely because of the too heavy teaching burden and too little laboratory facilities. Only one of them mentioned the matter of salary.

What these men wanted was a chance to do their work. That is also what the world wants of them and it is what every university must want. To use a man who has it in him to enlarge the sphere of human understanding for work that some one else could do as well is the most expensive kind of waste. Every teacher in a college ought to have, so far as possible, the sort of tools he needs, including laboratories, and not too great a teaching load. On the latter point there will be, it is true, some difficulty in making the adjustment. One man, primarily a teacher, should probably devote all his time to teaching. Such a man's inspiration comes to him as he speaks. Another's greatest service is research, another's writing, another's to commune with the universe. One does his best work lying on a mountain in the sun, another perhaps when he is shaving. I do not mean that the university should supply mountains and shaving materials, but that every teacher should have the time and opportunity not only to do his work but to seek the sources of his strength, and should even when necessary be forced to do so. He should have, so far as possible, the amount and sort of teaching that is good for him—not necessarily what he wants but what an experienced trainer would prescribe, neither too much nor too little but just enough to keep him fit. It is true no dean or president is or ever will be endowed with the superhuman insight to prescribe precisely the desired stimulus, but that should be the aim.

I have been much struck, as an overseer, with the degree to which the Harvard Corporation is alive to the value of the sort of economy in professors that I have indicated. By increasing laboratory facilities not only in psychology but so notably in the departments of chemistry and of biology, by providing clerical assistance in various departments and funds for publication, by decreasing the teaching load of members of the faculty who have shown a special gift of authorship, by the increase in salaries, with the resulting decrease in worry and in the output of pot boilers, and in other ways, it has so far as funds permit released the powers of its teaching force. Surely Harvard has come a long way since the days when, as noted by Henry James in his life of President Eliot, sophomore and junior compositions were corrected by Professor ("Stubby") Child.—*Joseph Lee, '83, in the Harvard Alumni Bulletin via School and Society*

RESEARCH FOUNDATION OF THE UNIVERSITY OF WISCONSIN

The Wisconsin Alumni Research Foundation has presented to the board of regents of the University of Wisconsin a report reviewing the results of its work during the first five years of its existence.

The foundation, the first of its kind inaugurated at a university, was incorporated on a non-profit sharing basis on November 14, 1925, and had as its avowed purpose "to promote, encourage, and aid scientific investigations and research at the university, and to assist in

providing the means and machinery by which the scientific discoveries and inventions of the staff may be developed and patented, and their public and commercial uses determined."

It is pointed out that the methods pursued by the foundation have the advantage of securing patent protection and that the income from such patents is used for the support of research which is in general for the benefit of the public.

Starting with nothing more than the willingness of DR. HARRY STEENBOCK to turn over to the foundation an idea that was subject to patent in order to protect it from misuse, the organization already has earned an invested capital of $406,594, the income from which is now being used to protect its patents and for the public welfare through the furtherance of scientific research.

On June 1 of this year the foundation made use of its right to control the price of two of the products based on the Steenbock process by bringing about a 25 per cent reduction in the price of these products to millions of consumers the world over.

Besides making possible these products, the discoveries of Professor Steenbock on the development of vitamin D in activating pharmaceutical and food products have been shown to be of material value to health, especially in the fortification of food intimately connected with the nutrition of the young, the health-giving properties of the process are now to be applied to the dairy field.

Holding that it is better to offer the discoverer some financial recognition for the large amount of work he had done, memorandum agreements were worked out by which, after all expenses had been repaid, 15 per cent of the net proceeds from the patents go to the discoverer or inventor, while the remaining 85 per cent is received by the foundation.

At the present time 11 patents or applications on discoveries made by university men are the property of the foundation. Most of these have been patented in nearly all the leading countries of the world.

Following three general principles for guidance in the allocation of funds for research, the foundation began to give aid to research during the fiscal year 1928–29. To stimulate interest in the graduate body of the university, a lectureship in science was established, and at the same time aid was given to certain definite lines of scientific endeavor.

During the coming year, aid will be extended by the foundation to nine different projects in research. The sum of $21,500 for grants-in-aid to these different research projects has already been allocated by the foundation trustees.—*Science*

THE GROWTH OF COLLEGE AND UNIVERSITY EDUCATION IN THE UNITED STATES

College and university education has shown a remarkable growth in the United States in the past ten years, both as to enrolments, variety of courses offered, income and property, Walton C. John, associate specialist in graduate education, announced in a survey made public by the Federal Office of Education on July 6.

The annual income of the institutions now totals more than $500,000,000 while the total value of property approximates nearly $2,500,000,000. Twenty-two publicly controlled and 162 privately controlled institutions have endowments valued at $1,000,000 or more each. Nearly 870,000 students are reached now by 1076 institutions of higher learning, which granted almost 97,000 degrees in 1928.

For the 25 years preceding the war the number of colleges and universities remained practically constant. In 1916–17 the number reporting was 662, including 82 junior colleges. In fact, during the 25-year period mentioned there had been a slight decline in the number of universities and colleges, and even by 1920 the total number had reached only 670. However,

in 1926 the number had increased to 975, and in 1928 to 1076, an increase of 107 institutions reporting for the biennium and 412 for the nine-year period.

The growth of the student body in the colleges and universities has been very great. In 1920, the enrolments, excluding preparatory students, reached a total of 462,445; in 1926 they reached 767,163; and in 1928 they were 868,793, an increase, respectively, of 65.9 per cent and 88 per cent over the enrolments for 1920. The enrolments in 1928 were 8.8 per cent greater than those for 1926.

The colleges and universities in the United States in 1928 granted 83,065 baccalaureate degrees. In 1926 the figure was 71,529, and in 1920 it was 38,552. This represents an increase over the 1920 figure of 85 per cent for 1926 and 115 per cent for 1928.

The number of graduate degrees granted in 1928 was 13,834, of which 1447 were the Ph.D. degree. In 1926, 11,451 graduate degrees were granted, which included 1302 Ph.D. degrees. In 1920, 4853 graduate degrees were granted, including 532 Ph.D. degrees.

The total income for the 1076 institutions reporting in 1928 was $546,674,266. Excluding additions to endowment, the income was $496,529,309. The total income for 975 institutions in 1926 was $479,774,664, and excluding additions to endowment it was $47,400,056. In 1920 the total income for the 670 institutions was $240,141,994, and excluding additions to endowment it was $189,235,242.

In 1928 the publicly supported institutions received 41.1 per cent of all higher educational income and the private institutions received 58.6 per cent. The increase in income is shown also. In 1928 the total income of all colleges and universities was 21.9 per cent higher than that of 1926 and 162 per cent higher than that of 1920. In 1928 the public institutions received an income 17.9 per cent greater than that of 1926, and the 1928 income of private institutions was 24.8 per cent greater than that of 1926.

The total value of property for the 1076 institutions in 1928 was estimated at $2,413,748,981; in 1926 it was $2,334,307,421, and in 1920 it was $1,257,614,739.

A comparison between the amounts and proportions of the value of property of publicly and privately controlled institutions is given. As the figures for 1919–20 cannot be segregated, it is necessary to compare the figures of 1921–22 with those of 1927–28.

The value of all property, including productive endowment funds, in publicly controlled colleges and universities in 1921–22 was $360,184,477; in 1927–28 it was $664,290,782. This indicates an increase in six years of 84 per cent.—*School & Society*

MASTERS OF COLLEGES AT YALE UNIVERSITY

Announcement of three masters of colleges was made by PRESIDENT ANGELL at the recent alumni luncheon at Yale University. Dr. Angell said: "We have been keenly aware of the need that science should be adequately recognized in our new Quadrangle Colleges, and I am happy to announce the appointment by the corporation of three new masters representing not only scientific interests in general, but in two instances representing directly the Sheffield Scientific School.

"I take great pleasure in announcing, first the appointment of DEAN CHARLES HYDE WARREN, of the class of 1896 Sheffield Scientific School, who has served with distinction for nine years as dean of the Scientific School and who had, prior to that time, achieved a notable reputation as a member of the geological faculty of the Massachusetts Institute of Technology. I need not enlarge upon his obvious fitness for one of these new and highly responsible posts. We regard ourselves as peculiarly fortunate in securing his services, not only because of his personal and professional qualities, but also because of the marked advan-

tages during the period of adjustment to the new plan of having in the council of head masters the dean of Yale College and the dean of the Sheffield Scientific School, both of whom are now enlisted in this new and significant development.

"I announce next the acceptance of a mastership by one of the leading bacteriologists of the country, DR. STANHOPE BAYNE-JONES, who comes to us from the University of Rochester in 1932 as master of college and professor of bacteriology. Graduate of Yale College in 1910, of Johns Hopkins Medical School in 1914, and professor and head of his department at Rochester since 1923, he has been widely recognized for his outstanding scholarship and administrative abilities. He saw continuous and active service during the war, first with the British Army and afterward with the American Expeditionary Force. He has both the British Military Cross and the Croix de Guerre, and was repeatedly cited in connection with the general orders of the 26th Division of the United States Army. This year he is vice-chairman of the Division of Medical Science of the National Research Council and next year will be its general chairman. We are securing in him a man of distinguished scientific attainments and with the personal qualities which are so indispensable for the successful execution of the duties of the college masterships.

"I have to mention third the appointment of PROFESSOR ELLIOTT D. SMITH, of the Sheffield Scientific School, a graduate of Harvard College in 1913 and of the Harvard Law School in 1916, where he took extremely high rank and was case editor of the *Harvard Law Review*. Subsequently he practiced law in Chicago, during the war became connected with the Council of National Defense, and was director of research for the Tariff Commission in 1919. He was connected with the Dennison Manufacturing Company from 1919 until he came to Yale in 1928, and while there was division manager in charge of an extremely important section of that large and flourishing company. Since coming to Yale he has made a position of marked distinction for himself, has published widely, particularly on the side of personnel management, and is everywhere recognized as a man of forceful and imaginative intelligence and with the finest personal qualities.

"With these three new members of the council of head masters, we are willing to believe that there will no longer be any question of the conspicuous position which science is to occupy in the organization of the new colleges. We thoroughly disbelieve in the disposition to exclude science from the group of the true humanities. We believe that in the modern world science properly conceived is at the very heart of humanistic studies and our present action in bringing these three distinguished men into charge of new colleges is testimony to our faith."—*School & Society*

THE ALUMNI UNIVERSITY OF THE UNIVERSITY OF MICHIGAN

The Alumni University at the University of Michigan [*cf.* J. CHEM. EDUC., **8**, 1655–6 (Aug., 1931)], which was held over a period of five days from June 23 to June 27, enrolled 92 alumni students. This is an increase of 20 over the number returning for the first session held last year. The program this year included ten series of five lectures in philosophy, drama, child psychology, music, art, economics, heredity, geology, local government, and social evolution. These were given by ten different members of the faculty, with the program so arranged that an opportunity was furnished for those enrolled to attend a maximum of five lectures daily. Many of those enrolled followed out the whole program from nine o'clock in the morning until three in the afternoon and the courses were all equally well attended.

A special reception was held on the opening night at the William L. Clements Library of American History, when DR. RANDOLPH G. ADAMS, director of the

library, gave an illustrated talk on the Gage and Clinton papers.

The alumni attended performances of Noel Coward's "Private Lives," Ibsen's "Ghosts," and Shaw's "Arms and the Man," given in the Lydia Mendelssohn Theater. This program was given by a company which included TOM POWERS, VIOLET HEMING, and ERNEST COSSART of the Theater Guild.

Of those enrolled, 79 were alumni of the University of Michigan. Eight were husbands or wives of alumni in attendance, and five were graduates of other institutions. Four were graduates of the Engineering College, six of the Law School, and four of the Medical School. Seven held degrees from the Graduate School. While a large proportion of those enrolled, 68, were registered from the State of Michigan, 6 came from New York State, 5 from Pennsylvania, 3 from California, and 3 from Illinois.—*School & Society*

THE INCREASE OF HIGH-SCHOOL STUDENTS IN NEW YORK CITY

The expected registration in the New York city high schools of 205,000 students in the fall of 1932, an increase of 25,000 over the last term, will make necessary the appointment of more than 1000 additional teachers. According to DR. HAROLD G. CAMPBELL, deputy and associate superintendent of schools, in charge of high schools, this would be the largest increase in teaching positions ever allowed by the Board of Education at one time for day high schools. Of these positions, 400 would be needed for the fall of this year and the remaining 600 for the spring and fall terms of 1932. Their employment will raise the salary budget for high schools in 1932 to more than $30,000,000, an increase of nearly $3,000,000 over this year. An additional $100,000 also will be expended for supplies.

The registration in the high schools at the close of the 1930–31 school year was in the neighborhood of 180,000. It is expected that 189,000 will be registered in October; that 201,000 will be registered in the spring of 1932, and that by the fall of 1932 this registration will have increased 4000 more to the unprecedented total of 205,000.

Despite the large increase in registration, Dr. Campbell explained that there had been a decrease in the *per capita* cost of instruction in the day high schools during 1930. He said the *per capita* cost in the high schools was $170.93 during last year, in comparison to $174.66 in 1929 The *per capita* cost per hour was $0.17576 in 1929, and $0.17126 last year. In 1928 the *per capita* cost per hour was $ .18081.—*School & Society*

CHILDREN ARE MORE ALERT THAN THEIR TEACHERS

That children's queries show they are far more alive to their mental requirements than the educators who prepare courses of study for them is the belief of PROF. R. A. BAKER of the College of the City of New York. Prof. Baker is secretary of the Division of Chemical Education of the American Chemical Society.

It is the children who are awake and the educators who are asleep, declared Prof. Baker. "No child is too young to learn chemistry, for example, yet we have ruled that until a student reaches a certain year in high school he is not sufficiently advanced to undertake the study of this science.

"We have been all wrong. Children should be taught about the things that come into their daily life and experience. The earliest questions asked by the child deal with such things as 'What makes the fire burn?' and 'What is fresh air?' These are frequently answered inaccurately because it is believed that the child is too young to understand scientific processes.

"It is time that we were awakening to the fact that chemistry does not belong to the chemists but to the whole world. There are many things about chemistry that, if properly presented, kindergarten children could grasp. Chil-

dren have the right to a full and useful education and this of necessity includes a study of chemistry.

"Some of the makers of games and educational toys have been keen enough to appreciate the type of thing which naturally appeals to children and have developed various experimental sets to answer this need. Unfortunately, the misguided use of this material frequently leads to entirely incorrect conclusions and mistaken ideas. . . . The time is coming when educators will no longer be able to impose arbitrary age limits governing the study of science or any other subject."—*Science Service*

"SCIENCE RESEARCH REQUIRES SALESMEN," SUBJECT OF DR. BANCROFT'S DEDICATORY ADDRESS AT THE UNIVERSITY OF SOUTHERN CALIFORNIA

A great scientist must also be a great salesman if he wants his discovery to be understood and welcomed in his own time. This idea was advanced at the dedication of the Science Hall of the University of Southern California by PROF. WILDER D. BANCROFT of Cornell University.

There is more danger of a great new idea's not being accepted than most people realize, said Prof. Bancroft. To be received by the multitude of non-discoverers an idea must obviously be acceptable to them in some way or other. This is one of the most fundamental of all questions involved in human progress and at the same time one of the most difficult.

Quoting a great chemist of last century, Prof. Bancroft continued, " 'When the prospective genius has done his great work and has communicated it to the world, one likes to think that he can go quietly to bed and wake up famous the next morning.' This, however, hardly ever happens. Very often the work of getting the new idea accepted is scarcely less than that of originating it.

"In many cases the man who has had the idea is not able to get it accepted and this task falls to the lot of another man who may be less clever, but who speaks a language which makes the world conscious of the treasure which it had been offered in obscure words."

Prof. Bancroft said that a new discovery is accepted for one of four reasons. It is accepted because it is made by a man of recognized authority or of personal magnetism, because it clears up points over which people have puzzled or because it shows what to do next, because of extensive proofs, or because the results are useful or striking.

If a good idea falls flat it is customary to say that the time was not ripe for it. However, it may be possible in some cases to change the temper of the time or as Prof. Bancroft said, to "ripen time." "To ripen time," said Prof. Bancroft, "we must establish our view by many proofs; we must discover something for which the world is ready; we must educate the world up to our discovery; or somebody else must educate the world for us."

Dr. Bancroft gave many examples to show that new discoveries had often to wait many years before being accepted by scientific men. Avogadro's law, fundamental in modern chemistry, was formulated in 1813 but had to wait over 40 years before trained chemists really understood and believed in it.

A Russian chemist, Lomonossoff, who lived from 1711 to 1765, had views on oxidation, the wave theory of light, and the nature of heat that were from 50 to 100 years in advance of his time. Thus credit for his discoveries, which were many, has been distributed among others. Even today his name is little known. It is only a few years since his work was rediscovered and reprinted by a fellow-countryman.

"One cannot count on having some one else exploit one's discoveries and the worker in pure science will not and should not limit himself to discovering only those things which the world knows that

it wants," concluded Prof. Bancroft. "Consequently, he must make up his mind to sell himself to the scientific world....Since the greatest discoveries are likely to be the ones for which the world is least ready, we see that the greatest scientific men should really be super-salesmen."—*Science Service*

MOLECULES AS MUCH SMALLER THAN MAN AS STARS ARE LARGER, ACCORDING TO DR. SWANN

Molecules, the tiny unseen building-blocks of all matter with which the physicist juggles, are as much smaller than a man as the stars are larger.

This striking scale of sizes was set forth in a radio address by DR. W. F. G. SWANN, director of the Bartol Research Foundation of the Franklin Institute, delivered under the auspices of *Science Service* over the network of the Columbia Broadcasting System.

Dr. Swann said, in part:

"Science teaches us that the objects which we see around us and which present to our vision a continuity of structure—the chair, the table, our own bodies—are really aggregates of much smaller things which our eyes could see as separate entities had nature designed them to that purpose. In a crude sense, the stars are to the great nebulae what the atoms and molecules, of which matter is made up, are to the objects of every-day experience. Between the atoms and the stars, man stands about half-way in magnitude, for it takes about a thousand-million-million-million-million atoms to make a man and about ten times this number of men, boiled down and seasoned with the necessary ingredients, to make a star.

"Apart from minor differences, concerning which only the specialist worries himself, there are about ninety-two different kinds of atoms. Like human beings, these atoms seek out from their fellows the particular individuals which happen to be especially agreeable to them and form associations of different degrees of polygamy known as molecules. At one time, it was believed that an unmarried atom had no place in nature, although he might leave one family and join another; and so the molecules were regarded as the smallest entities which could maintain a separate existence, and the atoms as the smallest things which could separate themselves off from one of those molecules, even with the promise of an immediate new alliance. Now we know that there are bachelor atoms, but either they retain their bachelorhood for only a very short time or they are very docile atoms, like helium, which have so very little affection even for each other that they prefer to live apart, and get so little excited about matters in general that they never flare up in any company and so are found very safe beings with which to fill our dirigibles.

"The imagination of man is taxed almost to the limit to comprehend the magnitude of the stars, but it is taxed to no less a degree to comprehend the smallness of the atoms and molecules. I should like to cite an illustration once given by DOCTOR ASTON of Cambridge University:

'Suppose that we should take an ordinary glass of water, and suppose that we could label the molecules in that glass so that we should know them again. Let us empty the glass of water into the middle of the Pacific Ocean; and, after it has become mixed up with all the waters of the world, let us go to the nearest faucet and fill that glass once more. How many of the original molecules will be found in the glass? The answer is, about 2000.

'It is highly probably that there is in the body of each one of us a number of atoms which went to make up the blood of Julius Caesar. The story as regards Napoleon is not quite so true. He is not yet "mixed up" enough.'"—*Science Service*

CHEAPER HYDROGEN FOR INDUSTRY PROMISED

Cheaper methods of making hydrogen from powdered fuel were discussed by

DR. A. THAU of Berlin at a joint meeting of the Institute of Fuel and the Institute of Gas Engineers in London. Apart from its use in domestic gas, industrial hydrogen is in increasing demand for the synthesis of ammonia gas for the hydrogenation of oils, and probably in the near future will be used for the liquefaction of coal.

The hydrogen is separated from so-called water gas which is made by the action of steam on red-hot coal or coke.

Great efforts have been made in recent years to reduce the price of water-gas by utilizing a cheaper fuel, as production costs are comparatively high. At present the process depends on the use of high-class lumpy fuel such as coke or coal which is free from small particles.

Dr. Thau pointed out that the size of the fuel is not of so much importance as evenness of grain, which allows an evenly distributed passage of gas over the whole area of the fuel bed in the "producer," where the chemical action takes place.

The first continuously operated water-gas producer to consume powdered fuels instead of lump fuel, continued Dr. Thau, was designed by DR. OSWALD HELLER of Aussig, Czechoslovakia. Exhaustive trials of the system have been conducted at the Tegel works of the Berlin Gas Company. The producer is of horizontal cylindrical shape and superheated steam is blown into it at seven different places.

The trials have not yet reached a conclusive end, but water gas can be produced by this process considerably cheaper than previously.—*Science Service*

SUBSTANCE OF DIGESTIVE JUICE PREPARED PURE

The digestive ferment of the stomach that dissolves the starch in foodstuffs, and makes it available for the energy needs of the body, has been prepared in the pure state for the first time in the chemical laboratories of Columbia University, New York City.

This marks an important step toward finding out what these complicated ferments really are, a problem that has hitherto remained unsolved because they could not be obtained pure.

PROF. H. C. SHERMAN, who is well known as an authority on the vitamins, and two associates, PROFS. M. L. CALDWELL and L. E. BOOHER, announce their accomplishment in a report to the journal, *Science*.

Starch, under the action of this ferment, is converted into malt, and this being also the first step in the preparation of fermented liquors from grain.

The crystals of diastase or amylase, as the starch ferment is called by chemists, were obtained from solutions of the pancreatic extract in a mixture of alcohol and water. The crystals show resemblances to proteins, those nitrogen-containing compounds which form so large a part of the stuff of the body. Because of this the crystallization must be carried out with very slight changes in temperature and the amount of acid in the solution controlled accurately.

This is the third digestive substance to be isolated. Protease, also found in digestive juice, which digests proteins like gelatin or the casein of milk, was recently crystallized by DR. JOHN H. NORTHROP and DR. M. KUNITZ at the Rockefeller Institute for Medical Research at Princeton, N. J.

Urease, the enzyme that transforms urea into ammonium carbonate for plant use, was first made crystalline in 1926 by DR. JAMES B. SUMNER at the Cornell Medical College.

The enzymes or ferments play a very important part in the life processes of plants or animals. They accelerate chemical reactions without themselves being used up in the process. Chemists call such substances, in general, catalysts; though enzymes are very special kinds of catalysts which are extremely unstable and therefore difficult to handle in the laboratory.—*Science Service*

VITAMINS A AND B PRINT INITIALS ON PHOTO PLATES

Two of the vitamins, A and B, apparently give off some kind of a radiation that will affect the emulsion on a photographic plate in the same way that light and X-rays do. This is indicated by experiments performed by two women scientists, SOPHIE BOTCHARSKY of London and ANNA FOERINGER of Paris.

In the British scientific journal, *Nature*, they report as follows:

"Photographic plates were covered with aluminum foil and letters were cut out of the foil covering the glass side. Extracts of vitamins A and B, biologically tested, were used to paint the letters VA and VB on the glass side. The vitamin A used was ether extract of dried ox-liver, the solvent being removed in nitrogen. Vitamin B was water extract of purified brewers' yeast. The plates, wrapped in black paper, were left for three days; on development, clear images of the letters were obtained.

"To confirm the results, vitamins A and B were sealed in two separate glass tubes, and the experiment was repeated. Very sharp images were again obtained.

"An extract of vitamin A prepared in a Paris research laboratory was investigated in the same way. It also gave positive results.

"Vitamins destroyed but not carbonized did not affect the plates.

"Two solutions, one ten times stronger than the other, of vitamin A in paraffin oil and vitamin B in water, were compared. The plates showed clearly difference in strength. Control experiments of pure solvents gave unfogged plates.

"It is interesting to note that the effect of vitamin B is similar to that of vitamin A, although the two vitamins are of different origin.

"The experiments were repeated several times, and the same definite effect was present. We are proceeding with our research into these effects."—*Science Service*

GIFTS AND BEQUESTS TO UNIVERSITIES AND COLLEGES

The New York *Telegram-World* reports that although official figures are not available, it appears that benefactions to higher institutions of learning have been larger during the depression than before. Counting only substantial contributions announced, the total donated to some of the more prominent eastern institutions approaches $75,000,000. Public gifts and bequests to the same colleges and universities in the year ended in June, 1930, totaled about $50,000,000.

The account in the *Telegram-World* continues:

About one-third of the money given is to be used for building. Never before, it appears, have American colleges and universities been engaged in such an extensive program of physical expansion.

Among the heaviest contributors, as usual, have been EDWARD S. HARKNESS, JOHN D. ROCKEFELLER, JR., the GENERAL EDUCATION BOARD, and the CARNEGIE CORPORATION. There were two other outstanding bequests, one of from $10,000,000 to $25,000,000, by the WENDEL estate to Drew University, and $3,159,766 left to Yale by the will of MRS. SARAH WEY THOMPKINS.

Harvard, according to an unofficial estimate, tops all universities except Drew in gifts received. It has announced receipts of $14,571,697, compared with $11,265,775 last year. Included is the $4,410,239 gift of Mr. Harkness for the new house plan, an unrestricted gift of $2,261,800 by the estate of STUART WYETH, a scholarship fund of $1,280,193, established by the estate of WALTER HASTINGS, the $1,025,155 ARTEMUS WARD memorial fund and $1,001,973 from the INTERNATIONAL EDUCATION BOARD for a new biological laboratory.

Mrs. Thompkins' gift to *Yale* will be used for a surgical building, a new headquarters building for athletics and endowment. Total gifts to Yale were more than $12,000,000, compared with $22,050,074 in the previous year, when the university received large gifts for a new house plan and on its completed endowment drive.

During the last year $1,018,000 has been received on endowment pledges, $2,000,000 for maintenance of the Sterling Library, $1,500,000 from the JOHN W. STERLING estate for five professorships, $1,154,961 for the MARY E. HAWLEY fund and $1,021,020 additional from the estate of CHAUNCEY M. DEPEW.

Columbia received $2,500,000 in two large gifts, one of $2,000,000 by the will of EDWIN B. PARKER to establish a school of international relations and another of $500,000 from EDWARD HARKNESS to be added to the $2,000,000 he had previously donated for residence buildings at the Medical Center.

Columbia also announced the gift of a huge library building by Mr. Harkness, the amount of the gift being kept secret. Gifts to Columbia in the previous year totaled about $1,400,000.

New York University received about $3,500,000, including $2,000,000 under the will of DR. WILLIAM H. NICHOLS and $1,000,000 from the late MRS. EMMA BAKER KENNEDY.

Princeton received $1,250,000, including $500,000 from THOMAS D. JONES, lawyer and capitalist, for increasing faculty salaries.

CYRUS H. K. CURTIS contributed $1,000,000 unrestricted to the total of about $2,000,000 the *University of Pennsylvania* received.

Of the *University of Chicago's* more than $3,000,000 in gifts, $2,215,000 was donated by JOHN D. ROCKEFELLER, JR., for an international house.

Other large endowments were:

Amherst—$1,000,000 given by DWIGHT MORROW, EDWARD S. HARKNESS, the estate of HENRY C. FOLGER, and others, for six professional foundations.

Bennington—$1,261,969 collected toward the endowment for this new progressive women's college to be opened in the fall of 1932.

Boston College—$500,000 for a school of journalism given by the widow of WILLIAM TAYLOR, formerly of the *Boston Post*.

Cornell—More than $400,000.

Lafayette—$1,250,000 toward a $3,500,000 fund to be raised by 1932.

Massachusetts Institute of Technology—$500,000 by the will of WILLIAM E. NICKERSON, Boston inventor.

Mount Holyoke—$640,000, including $375,000 from the General Education Board.

Syracuse—A $500,000 building for citizenship and public affairs study from GEORGE H. MAXWELL.

Vassar—$399,290, including $125,580 for a gymnasium and sports building.

Carleton College—In Northfield, Minn., $1,500,000 from the General Education Board, with the promise of $4,000,000 if the college can raise an equal amount.

Carnegie Institute of Technology—Promised $8,000,000 by 1946 by the Carnegie Corporation if the institute can raise $4,000,000 within that time.

Wesleyan—$1,000,000 toward a $3,000,000 centennial fund sought.—*School & Society*

TUITION INCREASE AT SMITH COLLEGE

The board of trustees of Smith College has decided to increase the tuition fee by $80, effective with the class of 1935 entering next September. Room, board, and tuition will cost each student, except those living in co-operative houses at a lower rate, $1000 a year instead of $920, which has been the charge since the fall of 1926, when the tuition was raised from $300 to $400. The infirmary and laboratory fees of $10 each will be discontinued. Board and room will remain $500 a year.—*School & Society*

UNDERGRADUATE SCHOLARSHIPS AT COLGATE UNIVERSITY

Colgate University recently announced the establishment of eighteen new competitive entrance scholarships ranging from $1500 to $1000 for the four years of college. These scholarships were made possible by the will of the late COLONEL AUSTEN COLGATE, who was a trustee of the institution and who made Colgate a beneficiary to the extent of over $1,500,000, the income from which is to be devoted to the promotion of student scholarship. In addition to the entrance scholarships, two $1000 fellowships are provided for ranking seniors who are going on to graduate schools, and all undergraduates who maintain a superior standing will be eligible to receive scholarships graduated up to the full cost of tuition, $300.—*School & Society*

STAFF CHANGES AND STUDENT AWARDS AT GRINNELL COLLEGE

MR. HOWARD D. TYNER has resigned as instructor in chemistry at Grinnell College and MR. WILLIAM B. OELKE, Grinnell, A.B., '28, has been engaged to fill his place. Mr. Oelke received his M.S. degree from Holy Cross College, Worcester, Massachusetts, in 1929 and has been instructor in chemistry there for the past two years.

Of the thirteen awards of membership in Phi Beta Kappa Society in 1931 at Grinnell College, Grinnell, Iowa, four were made to majors in the department of chemistry. The four recipients of this honor are JOHN B. EISEN of Munich, Germany; BERNARD TEBBINS of Omaha, Nebraska; CARROLL CROWNSEA of Grinnell, Iowa; and RAYMOND TSENG of Peking, China. The first three men have been granted assistantships in chemistry for next year, Mr. Eisen and Mr. Tebbins at Brown University and Mr. Crownsea at New York University. Mr. Tseng will continue his study of chemistry at Oberlin College where he has been awarded a fellowship.

NEW SCIENCE SHIP ON WAY TO AMERICA

A new ship, the "Atlantis," built especially for scientific work at sea is now on the way to America but since she will go to work even on her maiden

voyage she will not arrive at her destination until about the first of September.

The "Atlantis" was built at Copenhagen for the Woods Hole Oceanographic Institution. She is a steel boat of approximately 380 tons displacement, 142 feet long, 29 feet beam, and 16 feet extreme draft. She carries a 250 Diesel engine, and can cruise under power alone for 3000 miles at eight knots; with sail she can extend her radius indefinitely. She carries two laboratories, and living accommodations for twelve or sixteen persons.

She left Copenhagen for Plymouth, England, a few days ago, and will set sail from the latter port about July 10 for Woods Hole.

On the way over she will turn from her course for two north-south profiles across the North Atlantic Drift, one on the longitude of the Azores, the other about fifty degrees west longitude. Another profile will be run off the coast of Nova Scotia. On these scientific runs special attention will be paid to the distribution of the smaller life of the sea in its relation to light penetration into the water and also to the capture of fish that swim at great depths. Chemical studies will also be made of the sea water at stations spaced between Europe and America.

The physical studies will be in charge of the commander of the "Atlantis," C. O. ISELIN, the biological work will be conducted under DR. GEORGE L. CLARKE, and the chemical researches will be made by DR. F. ZORELL of the Deutsche Seewarte.—*Science Service*

Age of Earth Is Over 2,000,000,000 Years. The age of the earth is at least two billion years. This is the verdict of a committee of scientists appointed by the National Research Council who have investigated for the past four years this basic problem of science.

The radioactive minerals uranium and thorium, which spontaneously disintegrate into lead, give the best clue to the earth's age. By carefully analyzing the radioactive minerals and their products in a sample of rock, it is possible to tell how long it has been in existence.

The oldest rock in the world whose age has been determined in this way is a piece of uraninite or uranium-bearing rock from Sinyaya Pala, Carelia, Russia. It is 1852 million years old and as it occurs in rocks that were intruded into the surrounding rocks, which therefore must be older, the scientists conclude that the age of the earth must be in round numbers at least two billion years.

Estimates of the age of the earth have been multiplied by more than twenty during the last three decades. The idea that the amount of salt in the ocean is an index of the earth's age was found by the National Research Council committee to be unreliable. Only a hundred million years can be accounted for by this method. This was a favorite figure for the earth's age at the turn of the century.

Prof. Alois F. Kovarik, Yale physicist, and Prof. Arthur Holmes, geologist of Durham University, England, explain in the National Research Council report soon to be issued the methods of age determination based on radioactive disintegration. They are based on the fact that the radioactive elements uranium and thorium disintegrate spontaneously at constant determinable rates and yield lead whose atomic weight varies according to the proportion contributed by its radioactive parents.

The chairman of the committee was Prof. Adolph Knopf of Yale. Prof. Charles Schuchert of Yale compared the radioactive age results with the evidence from the thickness of layers of the earth. Prof. E. W. Brown, Yale astronomer, concluded that while there are no known astronomical methods the two billion year age is consistent with astronomical probabilities. Prof. A. C. Lane of Tufts College was also a member of the committee.—*Science Service*

Recent Books

Second Digest of Investigations in the Teaching of Science. FRANCIS D. CURTIS, Ph.D., University of Michigan and University High School. P. Blakiston's Son and Co., Ltd., Philadelphia, Penna., 1931. xx + 424 pp. 13.5 × 19.5 cm. $3.00.

This Second Digest is similar in many respects to the First Digest of which it is really a continuation.

Volume I of "Investigations in the Teaching of Science" "was restricted to published investigations and to learning and curricular studies in the elementary and secondary fields." The second volume is expanded "not only to include other types of investigation besides learning and curricular studies, but also to represent the college field as well as the elementary and secondary fields."

The early volume abstracted 70 articles in scientific periodicals, reports, and theses bearing on investigations into different phases of teaching of the sciences, each abstract occupying about 4.5 pages. About one-third of the abstracts related directly, and many more indirectly, to chemistry. Each abstract covered (1) the problem to be investigated, (2) the method used, and (3) the findings of the author. Roughly the same treatment and the same relative proportion of space applies to the Second Digest.

Since the first volume covered investigations made prior to 1925 the problem of selecting the proper papers from the "hundreds of studies covering the various phases of the teaching of science" published in the last six years was "extremely perplexing." The following method was adopted. The 42 members of the National Association for Research in Science Teaching were asked "to suggest published and unpublished research investigations relating to any phase or phases of science teaching which the members considered to possess sufficient value to warrant their inclusion in a second volume." The resulting lists were combined and members were again asked to evaluate the separate papers. The outcome comprises the 93 studies of which abstracts are printed in this volume.

Although the abstracts are grouped under (1) elementary schools, (2) secondary schools, and (3) colleges, with subdivisions under the second group covering general science, biology, physics, and chemistry, there is necessarily more or less overlapping in content.

To forestall any criticism that the method of selection necessarily omitted many worthy papers, the compiler has inserted 7 supplementary lists of titles of studies "taken chiefly from the composite bibliographies from which these studies were selected." It is unfortunate that the complete composite bibliography was not included so that teachers of science could have referred to such unabstracted studies as touched individual needs.

There is much food for thought, both pro and con, in the introductory pages on "The Learning Studies" and "The Curricular Studies." In this connection it is interesting to note that, by actual count, of the 93 studies abstracted 16 are master's theses and 24 are doctor's dissertations.

The studies are reported without interpretation by the compiler. Tables are included only to the extent of giving a clear understanding of the nature of the study.

The preface states (*a*) that this book is adapted for use by those "engaged in training teachers of science" and by those "who are conducting advanced courses and seminars for the purpose of training graduate students to do research in the teaching of science," and (*b*) that it should serve as a "source book and a reference book" for workers in educational research, for administrators, supervisors, and classroom teachers of science.

The abstracting seems to be well and fairly done. For teachers of secondary-school chemistry the book should serve well as a starting point from which to carry on such independent investigations as they may wish to conduct.

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Laboratory Exercises in General Chemistry. JOHN A. TIMM, Assistant Professor of Chemistry, Yale University; ORION E. SCHUPP, JR., formerly laboratory assistant in chemistry, Yale University. The McGraw-Hill Book Co., Inc., New York City, 1930. ix + 138 pp. (half of these pages are blank). 16 illustrations. 14 × 21 cm. $1.25.

The purpose of the book is to provide laboratory exercises to accompany Timm's "An Introduction to Chemistry." [For a review of this book see J. CHEM. EDUC., **8**, 411–2 (Feb., 1931).] The authors admit encountering a difficulty in making a selection of experiments suitable for the accompanying textbook owing to the large amount of physics which that text contains. They have therefore frankly avoided the issue and have featured chemistry experiments of a quantitative character for the introductory experiments particularly. These are followed by an abridged qualitative analysis scheme as well as by exercises involving electrolytic procedure, colloids, and a bit of organic chemistry. Supplementing each exercise is a suggestive list of questions intended to drill the student in the principles concerned. There is very little in the manual which is not thoroughly familiar to every teacher of general chemistry. The usefulness of the book therefore lies precisely in the field for which it was written, namely, as a collection of experimental material suitable for illustrating a specific text.

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Modern Chemistry. CHARLES E. DULL, Head of Science Department, West Side School and Supervisor of Science for the Junior and Senior High Schools, Newark, N. J. Third edition. Henry Holt and Co., Inc., New York City, 1931. xii + 776 pp. 392 figs. 12.5 × 18.5 cm. $1.80.

In "Modern Chemistry" the aim of the author has been to produce a book for the high-school student that would show him the cultural and practical value of chemistry; cover the fundamental principles upon which the science is based including all necessary material needed to meet the syllabi of the College Entrance Board of the New York State Board of Regents, or of the various cities that have recently revised their courses of study; be so readable and understandable, due to the use of simple language well within the grasp of pupils of high-school age, that it would not be necessary for the instructor to spend valuable time in explaining.

The author has fulfilled his purpose and produced a book that is good in many ways. He has made it understandable by the clarity and simplicity of its explanations, by the inductive approach in which students are introduced to new phases of the subject by means of references to every-day life or to previously acquired scientific knowledge and by the use of simple language, plainly labeled line drawings and a wealth of illustrations.

Considerable space has been devoted to the mathematics of chemistry with explanations which have been simplified by the use of type problems throughout. The subject of writing equations has been developed by a step by step method which simplifies the presentation and stresses the points where so many students make mistakes.

The author has developed the theory in a clear, concise, logical manner and groups together, early in the book, the chapters dealing with atomic theory, atomic and molecular weights, valence, and chemical equations in a logical sequence which simplifies its presentation.

The book is thoroughly modern, containing many pictures and material on the latest practical applications of chemistry.

The electron theory is briefly introduced in an early chapter dealing with the nature of matter and its changes and later the application of this theory to the subject of valence is more fully discussed.

The book contains certain devices that not only are teaching helps but should aid the student to better understand the subject of elementary chemistry.

Among these are: keyword chapter vocabularies given at the beginning of each chapter which certainly is an excellent idea; type problems to introduce all mathematical relationships; chapter summaries which include the fundamental facts and principles studied; thought questions as well as many numerical problems; suggested projects with necessary references which should keep the accelerated student interested.

It is a book which the high-school student should find interesting, easy to read, and from which he should acquire not only the fundamental principles but the practical applications of modern chemistry.

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Introductory College Chemistry. HARRY N. HOLMES, Professor of Chemistry in Oberlin College. Revised edition. The Macmillan Co., New York City, 1931. viii + 550 pp. 153 figs. 14 × 21.5 cm. $3.25.

This revised edition of the author's well-known text maintains the general policy of the preceding ones. From the very first the author has tried to follow a middle course between the extremes of conservatism and radicalism. The success of each edition has apparently encouraged him to depart farther from the beaten path, without, on the other hand, adopting any fundamentally new plan of treatment of the subject.

"This revision keeps pace with the recent startling progress in industrial processes. For example, hydrogenation of petroleum and the newer methods of making industrial alcohols are clearly presented.

"Nitrogen fixation now looms so large before the world's eye that it is given a chapter of extended treatment. So, too, is the subject of fuels. The later developments, such as the Bergius 'liquefaction of coal,' and the recent radical changes in petroleum cracking processes are discussed.

"There has been no desire to omit the chapter on colloid chemistry, for that subject is growing with great speed, nor to give any less attention to the important group of chapters on organic chemistry, including nutrition.

"The student's vision, his intellectual horizon, is extended still more by the new chapter on photochemistry, something of an innovation in texts of this type. By photochemistry is here meant something more than photography and photosynthesis, although they are properly included in the treatment."

The book is most commendable for the way in which it handles the simpler industrial and commercial chemical processes. It will not be suitable for one who wishes a thoroughgoing theoretical textbook. It is written in an interesting, readable, and non-technical style, and should be best adapted to the use of elementary students not likely to become professional chemists. A new feature, useful to the general student, is a table in the appendix containing the approximate prices of various substances.

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Chemistry for Students of Agriculture and Home Economics. ROBIN CHARLES BURRELL, Ph.D., Assistant Professor of Agricultural Chemistry, Ohio State University. McGraw-Hill Book Co., Inc., New York City, 1931. xviii + 459 pp. 77 figs. 14 × 20.5 cm. $3.50.

The book is written with the purpose of presenting "a clear picture of the fundamental theories upon which the structure of applied chemistry rests, and of showing what chemistry means in practical, every-

day affairs." Although the book presupposes a year's course in general chemistry, it starts with a brief review of the principles involved therein, and continues through a discussion of analytical and synthetic chemistry, organic chemistry, biological chemistry, and the application of all of these to problems of especial interest to students of agriculture and home economics.

It is a tremendous task to include in such a small space this large volume of material, and to present the outstanding principles in a briefly summarized form. The book is, as the author states, an "abstract of the field of chemistry" adapted to a special purpose. The author has rigidly selected his material to include the established theories on which the science of chemistry is based, the important recent work on the structure of matter, hydrogen-ion concentration, the colloidal state, physico-chemical phenomena, and the excellent general discussion of biological principles and processes. In reading the text, one has the impression of concise organization of material, of logical sequence, and, as the author intended, of an unusual adaptation of the subject to the problems which are met in daily life.

The author explains that there is a demand for a chemistry course which may be given in a limited time and which will give students an appreciation of the methods of chemical analysis and a general knowledge which may be applied to their respective problems. For such a brief course, the text might be usable. However, students of home economics and agriculture would not be adequately equipped for the application of chemistry to problems they would be likely to meet unless they had a more complete course in organic and in analytical chemistry than is here outlined.

N. M. NAYLOR

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The Principles of Organic Chemistry. JAMES F. NORRIS, Professor of Organic Chemistry Massachusetts Institute of Technology. Third edition. McGraw-Hill Book Co., Inc., New York City, 1931. xii + 595 pp. 8 figs. 14 × 20.25 cm. $3.00.

This textbook has been so widely used by teachers and is now so well known that it would seem unnecessary to describe here its purpose and scope. It was originally designed to meet the needs of beginning classes in the subject and in this has been eminently successful. The great and sustained popularity which the book has enjoyed is an eloquent testimonial of the excellence of its general plan—the choice of subject matter, the organization of the material, and the style of presentation.

In the new edition these features have been retained and the work has been thoroughly revised particularly with respect to new industrial developments. Along theoretical lines, however, the author has been more conservative. For example, no advantage has been taken of the recent developments in valence theory; all bonds are written alike, even in the ammonium compounds, and there is no indication that they differ in type. On the other hand, the theory of partial valence which has outlived its usefulness continues to be emphasized. Large alicyclic rings and the present status of the Baeyer strain theory are not discussed. The treatment of the Beckmann rearrangement has not been altered.

A conservative attitude with regard to the inclusion of current theoretical developments is probably justified on pedagogical grounds. Certainly one of the chief merits of this textbook consists in the skilful handling or evasion of points which are so involved or of such doubtful value as to be likely to confuse the beginner.

Against these few points which many will criticize adversely may be set a host of striking improvements. The nomenclature has been greatly improved; the problems are new and excellent; the equations and structural formulas stand out very clearly on the page; the generaliza-

tions have been put in italics. The treatment is full enough to meet the needs of a year course; yet no one need hesitate to use this book in connection with briefer courses because the organization is so good that the less important sections may be passed over without seriously affecting the continuity.

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Laboratory Manual of Organic Chemistry. HARRY L. FISHER, Ph.D., Research Chemist, United States Rubber Co., Passaic, New Jersey, formerly Instructor in Organic Chemistry, Columbia University. Third edition, revised. John Wiley and Sons, Inc., New York City, 1931. xvii + 368 pp. 21 figs. 21.5 × 13.5 cm. $2.75.

The third edition of this excellent manual represents a critical and thoroughgoing revision of the previous edition, with an enlargement of thirty pages. A careful examination reveals a multitude of minor changes, and a considerable number of more striking changes, though the general character of the book remains the same.

Some of the more prominent additions are the following: the determination of the boiling point by Siwoloboff's micro method; tests to differentiate chlorine, bromine, and iodine in the experiment on qualitative elementary analysis; the preparation of butyl bromide by the acid method as an alternative for ethyl iodide by the phosphorus-iodine method; the preparation of amylene by dehydration of tertiary amyl alcohol, and re-hydration to the alcohol; an improved procedure for preparation of acetamide by the reflux method, and for its purification; an experiment to illustrate hydration of a nitrile to an acid; another to show decarboxylation; a safe procedure for the Skraup synthesis. The series of experiments leading from turpentine to camphor is retained. Suggestions and literature references for work on isoprene and rubber are given as a final experiment, which, like the preceding, can be assigned to the more advanced and capable students of a class.

New tests have been added to a number of experiments, including those on amides, amines, and aromatic halogen compounds. Improvements in procedure have been introduced into experiments on ethyl iodide, urotropine, hydrolysis of butter, diphenylmethane, sulfanilic acid, hydrolysis of ethyl acetate, etc.

Among other numerous changes may be noted the use of Nujol or Arochlor in the melting-point bath, the critical revision of stated boiling points and melting points, the deletion of some questions and the addition of others, the introduction of many new literature references, now indicated by the abbreviations used in publications of the American Chemical Society. The experiment on acetaldehyde-ammonia happily has been retired, and its place is taken by the depolymerization of paraldehyde.

The second part of the manual, devoted mostly to one of the best available accounts of combustion analysis for carbon, hydrogen, and nitrogen, is substantially as in the second edition. A few changes were noted: calcium chloride or dehydrite is recommended for water absorption in the Liebig method, permitting the omission of several long footnotes on dehydrated alumina; ascarite is now very properly given preference over soda-lime for absorption of carbon dioxide; the use of a Kipp generator to supply carbon dioxide for the Dumas analysis is now tolerated, provided the marble is first boiled with water; directions for analyses by the Parr bomb have been revised.

Some errors present in the second edition have been corrected, though one misprint persists on page 194: "9.3 grams (10.4 cc.) of aniline." The set-up for the preparation of ethylene (Experiment 8) seems to be somewhat complicated for so early in the course, and may consume an undue amount of time. A simpler outfit serves about as well. The preparation of an olefine by dehydration of an alcohol over alumina would perhaps make a de-

sirable alternative for the sulfuric acid method. The use of absolute alcohol in the preparation of ethyl iodide, and especially of ethyl ether, seems unnecessary.

The rather frequent recommendation to use a small fractionation column as an every-day aid in the laboratory is to be applauded, as it leads to purer products, sometimes to larger yields, develops a more critical attitude in the student, and is manipulatively much better than the usual rapid distillations from side-arm flasks. The familiar types of laboratory columns can be made by any glassblower, and the efficient Snyder column is now on the market in a student size.*

The manual gives examples of most of the operations important in elementary organic laboratory work, and of many of the important general reactions and methods of preparation. As in previous editions, the early experiments are described rather minutely, and each laboratory operation is treated in the same way the first time it is used. Throughout the book the directions are specific and clear, and valuable informative notes are appended in many places.

In the opinion of the reviewer this manual is more carefully and thoughtfully prepared from a chemical and pedagogical point of view than any other with which he is familiar. It is an especially good book for that fortunate but perhaps rather rare combination: the teacher who is willing to teach and the student who is anxious to learn. Depending upon the nature of the course, some of the questions may be omitted, but for the usual "long" course in college or university, preparation to answer any of the questions, and others which are pertinent, should be insisted upon. If the teacher is willing to do the necessary individual quizzing, the student will review his "theory," and examine reference books and literature references, in preparation for the quizzes and will be led to associate the laboratory work and the "theory" which it illustrates. This manual is well adapted to such a system of instruction, and if properly used will yield excellent results.

The format and typography are quite up to the Wiley standard.

E. C. WAGNER

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PHILADELPHIA, PENNA.

Qualitative Chemical Analysis. LOUIS J. CURTMAN, Associate Professor of Chemistry in Charge of the Division of Qualitative Analysis, The City College—The College of the City of New York. The Macmillan Co., New York City. x + 539 pp. 39 figs. 14.5 × 21 cm. $4.00.

This book includes procedures for the analysis of the anions and the cations, with directions for a systematic analysis of alloys and minerals soluble and insoluble. Considerable space is taken up with the discussion of theoretical principles, such as the theory of ionization, chemical equilibrium, solubility product, complexion formation, and oxidation-reduction. Emphasis is given to equations, particularly those involving oxidation-reduction. The book is divided into five parts. Part I deals with the theory of qualitative analysis and special apparatus. In Part II the metal ions and their reactions are considered very fully. Part III is given over to calculations in connection with solution, double decomposition, and oxidation-reduction reactions. Part IV contains preparatory work, preliminary experiments, and schemes for analyzing the cations. It also contains preliminary experiments on the anions, and analysis of simple substances. The last part takes up the anions in detail, and treats such special subjects as the interference of the anions in the analysis of the cations of Group III, the phosphate complication, the preparation of solutions for cation analysis, metals and alloys, and systematic analysis.

In accordance with the author's view, the book has been arranged in such a way that students who can spend only one semester in qualitative analysis can study the metals thoroughly and consider the

* Supplied by the Arthur H. Thomas Co., Philadelphia.

acids only briefly. However, this short course includes a thorough treatment of the theory, calculations, and laboratory work on cation analysis and the identification of simple substances. The material for this short course is given in the first four parts of the book. Part V is for those students who wish to take a second semester in qualitative analysis. This section considers anion analysis in considerable detail and also gives procedures for the analysis of complex mixtures.

The author has succeeded well in carrying out his intentions. The book is well written and is very nearly free of typographical errors. It appears that too much attention has been given to cells, and to the occurrence and properties of many substances. There is also considerable repetition. Much of it has resulted from the author's endeavor to make the book cover both a shorter and a longer course in qualitative analysis.

There is a wealth of material contained in the book. Numerous problems with their answers add to its value. Sections on equations and theory are especially good. It is the opinion of the reviewer that the book will be widely adopted.

M. C. SNEED
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An Introductory Course of Quantitative Chemical Analysis. HENRY P. TALBOT. Revised and rewritten by L. K. HAMILTON and S. G. SIMPSON of the Massachusetts Institute of Technology. Seventh edition. The Macmillan Co., New York City, 1931. xii + 253 pp. 8 figs. 14 × 21.5 cm. Price $2.50.

This revised, rewritten, and enlarged (50 pages) edition follows in material and general arrangement the sixth edition of 1921. The changes and additions include a thorough discussion and presentation of stoichiometric principles relative to the various procedures, together with numerous problems for application of the principles.

The changes in laboratory procedures include the analysis of chloride by the indirect precipitation method, the determination of sulfur in pyrites instead of barium sulfate, an expansion of the procedures of the analysis of brass to cover the analysis of bronze, and an introduction to the principles of potentiometric titrations.

The book is divided into three parts. Part I (7 pages) takes up general considerations of quantitative analysis and, among other things, stresses the necessity of accuracy and points out the methods by which it may be obtained. Part II (128 pages) is devoted to the subject of volumetric analysis. The correct use of measuring apparatus is first discussed, and then procedures for the determination of various substances by neutralization, oxidation, and precipitation methods are given. In Part III (93 pages) gravimetric analysis methods are discussed; also a number of procedures for the precipitation and conversion to weighable products, and calculations of the amount of desired substance are given.

In the Appendix (21 pages) the methods and apparatus for potentiometric titrations are outlined and several tables are given.

This book presents the fundamental principles of quantitative analysis in a correct manner. The stoichiometric treatment of problems is clear and thorough and is well designed to give students a fine understanding of this important phase of quantitative analysis. The problems after each discussion of stoichiometric principles are well chosen for the further development of and understanding by the student of the principles underlying volumetric and gravimetric calculations This is one of the new features of the seventh edition and has added materially to the value of the book from a teaching standpoint.

The procedures and methods of analysis cover a wide field and are ample to give a student a solid foundation in this important branch of chemistry.

The book is practically free from typographical errors and misstatements. We

infer that in general excellence this text has improved with each edition since 1897, and that its popularity and usefulness will be increased by the seventh edition.

H. H. BARBER

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An Introduction to Biochemistry. ROGER J. WILLIAMS, Ph.D., Professor of Chemistry, University of Oregon. First edition. D. Van Nostrand Co., Inc., New York City, 1931. xiv + 501 pages. 14 × 21.5 cm. $4.00.

This textbook is designed to give students of medicine, biology, home economics, and agriculture an acquaintance with the broader and fundamental aspects of the rapidly growing subdivision of science—biochemistry. The author emphasizes the fact that the chemistry of life is now becoming a subject of great interest to many organic chemists, and has endeavored to interpret in this text the important chemical and biological phenomena of the subject matter embraced under the general expression, "chemistry of organisms." A student who will follow closely the general discussion as presented in this book will acquire a good fundamental knowledge of the underlying basic principles characterizing the science of biochemistry. The author presupposes that any student to follow understandingly his text will have had at least one year's course in chemistry and an additional preparatory course in the principles of organic chemistry. A knowledge of the elementary topics of physical chemistry and familiarity with the basic principles of general biology are also very essential. The author acknowledges the assistance of several workers in this country, who have made important contributions in biochemistry, in the construction of his book, and the general arrangement and selection of topics for presentation indicates that the author has conscientiously endeavored to present a useful and instructive text. It is not easy to coördinate the literature of a field of science which is growing so rapidly as that of biochemistry today. Our ideas are changing rapidly and new facts are accumulating as the result of an enormous amount of research work. The book serves well, however, its purpose and should offer an easy opportunity for the new beginners to acquire important information and make an orderly approach to the further study of biochemistry.

The subject matter of the book is taken up under six sections covering in general the following topics:

1. Cell Structure, Living and Non-Living Portions of Organisms.
2. Nutritional Requirements of Organisms.
3. Mechanisms Used by Organisms in General for Promoting and Regulating Chemical Changes.
4. Metabolism of Single Cells.
5. Metabolism in Green Seed Plants.
6. Metabolism in Mammals.

As will be seen from reading these section headings, emphasis is laid on the biological aspects of biochemistry rather than the chemical. Stated briefly the author has endeavored to give information as completely as possible and to answer the following questions: (1) Of what are organisms composed? (2) What do organisms take from their environment during growth? (3) How do they maintain themselves during their life cycle? In the discussion of chemical transformations occurring in living organisms, the author has necessarily been obliged to restrict himself. To handle properly this feature of biochemistry would call for the construction of another very large book. The book fits in well with the modern advances of educational work in chemistry and should serve a useful purpose in general instruction in biochemistry.

TREAT B. JOHNSON

YALE UNIVERSITY
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Lehrbuch der allgemeinen Physiologie. ERNST GELLHORN, a.o. Professor of Physiology, University of Halle, at present Associate Professor of Physiol-

ogy, Oregon State University, and COLLABORATORS. George Thieme Verlag, Leipzig, Germany, 1931. xiii + 741 pp. 126 figs. 17 × 25 cm. M. 47.—, geb. M. 49.50.

Besides Professor Gellhorn, the editor, and author of the first section, pp. 1–232, on the Cell as a Physical-Chemical System, the following men have coöperated to produce the book: PROF. CARL OPPENHEIMER of Berlin, Section II, pp. 235–429 on the Chemistry and Energetics of Cell Processes; PROF. SPEK of Heidelberg, on The Cell as a Morphological System, pp. 431–52, and the General Physiology of Development and Attainment of Form, pp. 457–598; PROF. LEON ASHER of Bern, on the General Physiology of Excitatory Processes, pp. 603–81; and PROF. W. V. BUDDENBROCK, of Kiel, on the Tropisms, pp. 687–727. The names of the authors are a guarantee of the soundness of the contents of the book, since each is a master of his field.

The book as a whole is, however, disappointing. It aims to be and is rather a textbook than a handbook. It is not an exhaustive compendium and references are only sometimes given, although at the end of the chapters there is a pretty good list of references, mainly German, except in two of the chapters, where more detailed information can be obtained. Being written by a group of men it lacks unity. It is not a good textbook for this reason; and it is not a good handbook either. It cannot compare, for example, in interest and suggestiveness, with Bayliss' "General Physiology." Many of the chapters are very dull reading, but no one can read the whole volume without learning many new and instructive things. It lacks all philosophical outlook. Indeed it may be said, I think, that no editor would edit or compile a book of this sort if he had any philosophical outlook. There is no doubt a place for books of this kind, which give a fair compilation of present factual knowledge about some interesting things; but their usefulness is a limited one. The introduction states that the book is written for physicians as well as biologists; and no doubt any one who reads it will profit from doing so.

The best chapters, in the reviewer's opinion, are those by Prof. Spek. They are clearly and interestingly written, accurate, inspiring, critical, and written in an easy, flowing style. Prof. Oppenheimer brings much together in his attempt at the impossible task of presenting the whole of biochemistry in a few pages. Prof. Asher presents the recent important work on the importance of the time element in excitation. Both Prof. Spek and Prof. Asher dominate their subjects; but Prof. Gellhorn and Prof. Oppenheimer seem to be dominated by theirs.

I do not believe the book will live or will have more than a passing value.

ALBERT P. MATHEWS
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Annual Survey of American Chemistry. Volume V, 1930. Edited by CLARENCE J. WEST under the auspices of the Division of Chemistry and Chemical Technology of the National Research Council. Published for the National Research Council by the Chemical Catalog Co., New York City, 1931. 629 pp. 13 × 21 cm. $5.00.

This volume is uniform in format with its predecessors. Content and organization follow the established policies. Chapters which appeared in Volume IV but are omitted from Volume V are as follows: Oxidation-Reduction Potentials; Heavy Acids; Chromium; Nickel; Stereochemistry; Ceramic Products; Solvents and Lacquers; Synthetic Resins. For Electrochemistry has been substituted Application of Electrochemistry and for Rayon, Synthetic Yarns. New chapters are as follows: Subatomic Phenomena; Physical Methods in Analytical Chemistry; The Rare Earths; Cement and Concrete; Chemistry of the Silicates; Paints, Varnishes and Lacquers; Chemical Economics.

It is perhaps worthy of mention that, whereas Volume IV covered a period of

eighteen months and contained 549 pages, Volume V for the calendar year 1930 contains 629 pages—and this without any appreciable expansion in the discussion of the subjects covered.

OTTO REINMUTH
Associate Editor

Annual Reports on the Progress of Chemistry, 1930. Volume XXVII. The Chemical Society, London, England. Richard Clay & Sons, Ltd., Bungay, Suffolk, England, 1931. 13.5 × 20.5 cm. 10s. 6d. net (postage 6d.).

From the teacher's standpoint this survey is in many respects a more useful work than the American. While the range of subjects covered is of necessity somewhat limited, the scope of the reviews is international and a better picture of the progress of theoretical chemistry is presented.

The volume contains the following reports:

General and Physical Chemistry. By C. N. HINSHELWOOD.
Inorganic Chemistry. By H. BASSETT.
Organic Chemistry:
Part I.—Aliphatic Division. By E. H. FARMER.
Part II.—Homocyclic Division. By G. M. BENNETT.
Part III.—Heterocyclic Division. By S. G. P. PLANT.
Analytical Chemistry. By J. J. FOX and B. A. ELLIS.
Biochemistry. By A. C. CHIBNALL and J. PRYDE.
Geochemistry. By A. F. HALLIMOND.
Radioactivity and Subatomic Phenomena (1919–30). By A. S. RUSSELL.
Electrical Conductivity of Solutions. By (SIR) H. HARTLEY, O. GATTY, W. A. MACFARLANE, and D. M. MURRAY-RUST.

OTTO REINMUTH
Associate Editor

Algebraic Charts. EDGAR DEHN. Nomographic Press, New York City, 1930. 26 pp. 15.5 × 23.5 cm. $1.50.

This text consists of six charts by which it is possible by the use of graphical methods to obtain approximate values of the roots of various algebraic equations. Chart 1 is intended for the solution of quadratic equations with real roots; Chart 2 for cubic equations with real roots; Chart 3 for cubic equations with imaginary roots; Chart 4 for both quadratic and cubic equations with real or imaginary roots; Chart 5 for cubic equations with a real root; and Chart 6 for biquadratic equations with a real root. For Charts 2, 3, and 6 the equations to be solved must be converted into a special, "reduced" form; while in Charts 3 and 4 further computations are required before the final values of the roots are obtained.

As presented, the printed instructions must be followed by "rule-of-thumb" methods by those non-mathematically inclined. The final answers are then only approximate, conditioned by the accuracy of interpolation of a "straight-edge," which must be used to read various values from the charts.

These charts might be of service to teachers of mathematics in providing interesting applications of the principles of analytic geometry and of the theory of algebraic equations. "They would introduce into schools a bit of nomography whose educational merits have not sufficiently been appreciated."

CHAS. G. EICHLIN

UNIVERSITY OF MARYLAND
COLLEGE PARK, MD.

MISCELLANEOUS PUBLICATIONS

Special Jubilee Number, *Chemistry & Industry,* **July, 1931.** The Journal of the Society of Chemical Industry, Central House, 46 Finsbury Square, London, E. C. 2. 272 pp. Price, 10s.

"This special Jubilee Number of the Society's *Journal* contains not only historical information of interest to the members of the Society; it contains short biographies of many notable men and reprints of a number of papers published in earlier volumes of the Journal. These reprints should be of permanent value to those who investigate the history of the chemical industry."

The table of contents of this volume includes the following: Introduction, History of the Society, Portraits of members of the Council, History of the Sections, History of the Journal, Presidents and

Medalists, Original Members, Reprints of Papers, Some Early Advertisers.

Chemistry of Today. Broadcast Supplement of *The Nucleus*. No. 2. Published under the auspices of the Northeastern Section of the A. C. S., Inc., P. O. Box 1178, Boston, Mass., July, 1931. 52 pp. 15 × 23 cm. [For a notice concerning Supplement No. 1, see J. CHEM. EDUC., **8**, 1458 (July, 1931).]

The following radio talks sponsored by the Northeastern Section of the A. C. S. are recorded in this supplement.

"Chemical Question Box," M. J. AHERN pp. 23–5.

"The Chemist and Food Inspection," by HERMANN C. LYTHGOE, pp. 26–8.

"The Chemistry of Milk," HERMANN C. LYTHGOE, pp. 28–30.

"Chemistry in the Telephone Industry," by HAROLD D. REED, Part I, pp. 31–4; Part II, pp. 34–7.

"Why Should We Include Vitamins in Our Daily Diet?" by ARTHUR DUNHAM HOLMES, pp. 37–9.

"Glass Characteristics," by E. C. SULLIVAN, pp. 40–2.

"Chemical Question Box," by M. J. AHERN, pp. 42–4.

"Chemistry of Glass," by W. C. TAYLOR, pp. 44–7.

"Question Box Supplement," by M. J. AHERN, pp. 48–9.

"What Price Sunburn?" by JOHN A. SEAVERNS, pp. 49–52.

Record of Current Educational Publications. January 1–March 31, 1931. *Bulletin, 1931, No. 9.* Office of Education, WILLIAM JOHN COOPER, Commissioner. U. S. Government Printing Office, Washington, D. C., 1931. (For sale by the Superintendent of Documents, Washington, D. C.) 15 × 23 cm. $0.15.

Biennial Survey of Education in the United States, 1928-30. Vol. 1. Chapter XIII. College and University Education. WALTON C. JOHN, Associate Specialist, Graduate and Professional Education, Office of Education. *Bulletin, 1931, No. 20.* U. S. Dept. Interior. U. S. Government Printing Office, Washington, D. C., 1931. (For sale by the Superintendent of Documents, Washington, D. C.) 15 × 23 cm. $0.10.

Paper and Air Suggested as Ice-Box Insulation. Sheets of paper with a one-tenth inch air space between them may make a more satisfactory insulating material for the walls of ice boxes than the solid board materials now commonly used, it is indicated in a report to the American Society of Refrigerating Engineers by J. L. Knight of the General Electric Company.

The ideal insulating material would be nothing but air, if it transmitted heat by conduction alone, that is, the same way one end of a metal rod gets hot when the other end is heated, according to Mr. Knight's report, for the pure conductivity of air is much less than that of any commercial insulant now known.

"Unfortunately," it was stated, "radiation and convection may transmit several times as much heat as conduction, so that the net insulating effect is poor."

Radiation is the method of heat transfer by which the sun warms the earth, while heat is carried by convection as the result of the movement of air, as in heating a house by hot air.

Mr. Knight has found that the sheets of paper spaced about one-tenth of an inch apart and held in place by paper spacers effectively reduce convection and radiation without increasing conduction very much. He believes that this form of paper insulation would last a long time.—*Science Service*